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MEDICAL SCIENCE OF TO-DAY

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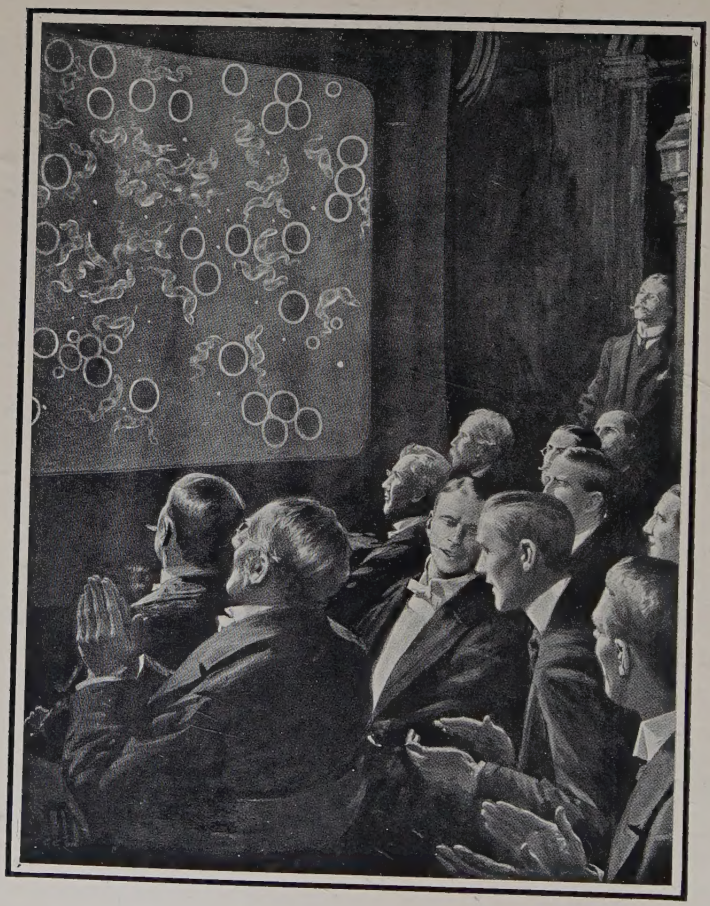

SLEEPING SICKNESS GERMS IN THE BLOOD OF A RAT

These are cinematograph pictures exhibited before a Medical Society, showing the movements and development of the microbe of sleeping sickness. The round bodies are the red corpuscles.

R.

MEDICAL SCIENCE OF TO-DAY

A POPULAR ACCOUNT OF THE MORE RECENT DEVELOPMENTS IN MEDICINE & SURGERY

By

WILLMOTT EVANS,

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With Thirty-one Illustrations

PHILADELPHIA

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LONDON: SEELEY, SERVICE & CO. LTD.

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PREFACE

THE object of this book is to give a simple explanation of some of the main principles on which are based the medicine and surgery of the present time. It has been written for non-medical readers, and the descriptions have been made as little technical as the case permits. I feel strongly that a wider acquaintance, on the part of the public, with the theories of the treatment of disease and injury will lead to a higher estimation of the value of medical science in the state. In the preparation of a book such as this I have necessarily been indebted to many works which I need not name, but I should like to mention my indebtedness to *The Prevention of Malaria*, by Sir Ronald Ross; to *Insects and Disease*, by Professor Rennie W. Doane; to *The Death-dealing Insects and their Story*, by C. Conyers Morrell; and to *Malaria, a neglected factor in the History of Greece and Rome*, by W. H. S. Jones.

I have also to thank Messrs. Longmans, Green and Co. for the use of Figs. 85 and 114 from *The Essentials of Practical Bacteriology*, by Mr. H. J. Curtis.

WILLMOTT EVANS.

HARLEY STREET,
LONDON.

CONTENTS

CHAPTER I

PAGE

INTRODUCTION 17

CHAPTER II

THE MEDICINE OF THE PAST 22

CHAPTER III

THE CAUSES OF DISEASE 29

CHAPTER IV

GERMS 40

CHAPTER V

THE MICROSCOPE IN MEDICINE 54

CHAPTER VI

THE MICROSCOPE IN MEDICINE (*continued*) . . . 63

CHAPTER VII

THE MICROSCOPE IN MEDICINE (*concluded*) . . . 73

Contents

CHAPTER VIII

PAGE

IMMUNITY 77

CHAPTER IX

IMMUNITY (*continued*) 88

CHAPTER X

VACCINATION 97

CHAPTER XI

DIAGNOSIS 107

CHAPTER XII

THE STORY OF THE DISCOVERY OF ANÆSTHESIA . . 123

CHAPTER XIII

ANTISEPTIC SURGERY 136

CHAPTER XIV

THE ARREST OF HÆMORRHAGE 151

CHAPTER XV

SHOCK 159

CHAPTER XVI

WHAT MODERN SURGERY CAN DO 164

Contents

CHAPTER XVII

PAGE

THE VALUE OF DRUGS 179

CHAPTER XVIII

ORGANOTHERAPY 190

CHAPTER XIX

MALARIA 198

CHAPTER XX

THE POLITICAL IMPORTANCE OF MALARIA . . . 204

CHAPTER XXI

THE RÔLE OF INSECTS IN THE PRODUCTION OF DISEASE 213

CHAPTER XXII

THE RÔLE OF INSECTS IN THE PRODUCTION OF DISEASE (*continued*) 224

CHAPTER XXIII

THE FIGHT AGAINST MALARIA 232

CHAPTER XXIV

INDUSTRIAL DISEASES 243

CHAPTER XXV

INDUSTRIAL DISEASES (*continued*) 251

Contents

CHAPTER XXVI

PAGE

LEGAL MEDICINE 258

CHAPTER XXVII

LEGAL MEDICINE (*continued*) 267

CHAPTER XXVIII

IDIOSYNCRASIES 285

CHAPTER XXIX

TREATMENT BY X-RAYS, BY RADIUM, AND BY FINSEN LIGHT 292

CHAPTER XXX

MALINGERING 306

CHAPTER XXXI

THE MEDICINE OF THE FUTURE 313

INDEX 321

LIST OF ILLUSTRATIONS

	PAGE
Sleeping Sickness Germs in the Blood of a Rat	*Frontispiece*
Gathering Mandragora	xvi
An Operation on the Liver	39
Crystals from Human Blood	60
„ „ the Blood of the Baboon	60
„ „ „ „ Horse	62
„ „ „ „ Squirrel	62
„ „ „ „ Goose	64
„ „ „ „ Guinea Pig	64
The Tsetse-Fly	78
Rat Flea	78
Mosquito (Female) of Malaria	78
An Amœba	92
A "Culture" of Diphtheria Bacilli	92
An X-Ray Photograph of a Foreign Body in the Gullet of a Child	120
A Broken Knee-cap soon after the Injury	177
„ „ united by Silver Wire	177
A Non-Malarial Mosquito (Female)	200
„ „ „ (Male)	200
Mosquito (Male) of Malaria	200

List of Illustrations

PAGE

LARVA OF MOSQUITO 218

MOSQUITO LARVÆ 218

EGG OF MALARIAL MOSQUITO: DORSAL VIEW . . . 220

„ „ „ SIDE VIEW . . . 220

MOSQUITO LARVÆ 220

BACILLI OF INFLUENZA 220

MOSQUITO OF YELLOW FEVER 226

FOOT OF HOUSE-FLY 226

ARMED AGAINST THE PLAGUE IN CHINA 228

A SAFETY CABINET FOR X-RAY OPERATORS . . . 294

TREATMENT BY RADIUM 302

From "Anæsthetics, Antient and Modern," by permission of Burroughs Wellcome & Co.

GATHERING MANDRAGORA

From a MS. of the Thirteenth Century

"To gather ye mandragora, go forthe at dead of nyght, and take a dog or other animal and tye hym wyth a corde unto ye plante. Loose ye earth round about ye roote, then leave hym, for in hys struggles to free hymself he will teare up ye roote, whych by its dreadfull cryes wyll kyll ye animal."

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MEDICAL SCIENCE OF TO-DAY

CHAPTER I

INTRODUCTION

In the Science of Medicine the problems presenting themselves at the present time are, in one way, very similar to those which came up for solution in the early ages of civilisation, yet in another way they are very different.

They are similar, for to-day we have, as they had in those bygone ages, to solve the problems of the origin, the diagnosis, and the treatment of disease. We have to find out why disease arises; we have to discover how to recognise it when it has appeared, and having diagnosed it, to treat it as effectively as possible, so as to prevent loss of life or limb. We have solved many of the problems that baffled our predecessors; we have tracked one disease after another to its origin; yet even now, after centuries of research, there are many diseases whose cause we do not know, there are many morbid conditions which we cannot yet diagnose with correctness and certitude, and there are even more diseases which we cannot cure. Nevertheless, all who have really considered the matter feel

confident that in time, with a persistence of that love for investigation and for the discovery of truth which characterises all true students of science, we shall know what is, as yet, unknown of these diseases, we shall have discovered the origin of each, and made its diagnosis and its treatment sure.

On the other hand, the medical problems of the present day are different, for now we are anxious rather to *prevent* disease than to *cure* it when it has already appeared. Medical men all over the world are now aiming, not at the discovery merely of the causes of disease and of its treatment, but of the methods by which its occurrence may be prevented. Every year we are learning more and more how to control diseases in their origin. Sometimes we endeavour to prevent the cause itself obtaining access to the body. Typhoid fever almost always originates from contaminated water or milk, so we endeavour to take precautions that no contamination of the sources of supply shall occur, or if for any reason this precaution be impossible, we employ means later to render the water or milk innocuous.

Sometimes the causes of disease are so widespread that they cannot be avoided, and then we may find that the best method of preventing an attack of the disease is by so strengthening the natural resisting powers of the body that it will be able successfully to overcome the assaults of the cause of the disease. Sometimes it is recognised that by improving the conditions of existence, by providing better ventilation, healthier sites, and more suitable buildings we may ward off dangers that would otherwise assail us.

How to carry out these objects completely and

effectively has become the most important medical problem of our time.

Similar attempts have no doubt been made in the past, but until recently the study of the causes of disease had not proved very fruitful, and therefore it was impossible for those who came before us to do what we, with our fuller knowledge of the causation of disease, are able to effect.

If we recognise, as we must, the all-importance of the prevention of disease, we have to acknowledge that success in carrying out the preventive measures which medical science has indicated does not depend only on the members of the medical profession. It depends on the Government, on every voter in the kingdom, and on every individual citizen; for without the co-operation of those who govern and those who are governed medical men can do nothing. Unless the country as a whole recognises the importance and the efficacy of the measures of prevention suggested, any attempts that may be made must fail. Sometimes by an active interference the passage of laws calculated to prevent disease will be hindered, but it is no less common for the apathy and mere inertia of the people to put insurmountable obstacles in the way of the progress of preventive medicine.

Much of the opposition, active or passive, on the part of the general mass of the public is due merely to want of knowledge. When the interference is active, the instigators of it are misled by preconceived ideas of the nature of disease, of its cure, or of its prevention. When the opposition is passive it is because the opposers are ignorant of how much can be accomplished by well-directed efforts and how valuable those results may be.

Introduction

No one knowingly exposes himself to dangers which are avoidable unless actuated by powerful motives. No one intentionally incurs unnecessary evils. If on the one hand the greatness of the risks that are run is fully realised, and on the other hand the ease with which those risks may be avoided is appreciated, none will oppose the measures needed for the prevention of disease.

If we agree that the mainspring of the opposition to hygienic measures, whether that opposition is intentional or not, is lack of knowledge, it is clearly only reasonable that means should be taken to educate the public mind on some, at least, of the matters which are now engaging the attention of the medical profession, on some of the problems which we are now endeavouring to solve. If this is done, there will be a hope that at least some of the opposition which we now encounter will be removed. Though naturally legislators must be for the most part dependent on the expert opinions with which they are supplied, yet they would probably be more ready to accept those opinions if they were more able to appreciate the grounds on which those opinions were based.

Moreover, if the members of the public were better acquainted with some of the facts of medical science, they would understand better than at present the marvellous intricacy of medicine and the difficulties that lie in the way of diagnosis; they would be less prone to resort to quack medicines and to place their trust in treatment which must rest on their own diagnoses. They would be more tolerant of errors of diagnosis and treatment if they appreciated more fully how difficult diagnosis and treatment may be.

Introduction

This book necessarily only contains a very small portion of the facts of the science of medicine. It endeavours to explain some of the more recent advances in the various branches of medicine and surgery, and it is intended to show the need for measures of prevention, which are advised or adopted. It is hardly necessary to say that no attempt has been made to give anything like a general account of medical science; that would have been of little use and in some ways possibly harmful; but an acquaintance, slight though it may be, with the general principles on which the modern science of healing is based can, in my opinion, be productive only of good.

CHAPTER II

THE MEDICINE OF THE PAST

To be able to appreciate more fully the advanced position held by medical science to-day, it is well to know something of the medicine of the past. Not that we may condemn the medicine as practised in ages other than our own, for the doctors in the past strove, as do those of the present day, strenuously to make advances in their science, but rather that we may be better able to gauge the enormous progress which has been made within recent years.

The origin of the medical art is involved in dense obscurity. The sciences of medicine and surgery as practised to-day are based, in part at least, on methods devised many thousands of years ago, which we know must have existed, not because we have any direct knowledge of them, but because we are led to deduce their existence from the traces they have left behind. Even in the world of the present day we have many opportunities of seeing how in early stages of civilisation the practice of medicine is pursued. Yet year by year it is becoming more difficult to find a savage race unaffected directly or indirectly by modern civilisation, and therefore it is becoming more difficult to discover a race where the habits and customs are purely those of uncivilised man. For, even in the least developed races still existing, many steps have been taken along the road which leads to civilisation, and therefore

even in these we must not expect to find medicine and surgery at their earliest stage. Everywhere, even in these very savage races, we find a wide knowledge of the value of herbs and roots and other natural products in the treatment of disease and injury, and this acquaintance with the properties of plants and minerals must have required many years, or rather many centuries, to bring about. In these lowly developed peoples the knowledge of the value of herbs is possessed by two sets of persons. Part of the knowledge resides in some of the older women of the tribe, who practise it in conjunction with nursing ; but more often still the medical art, such as it is, is associated with the priesthood. The "Medicine Man" of the tribe possesses a knowledge of the curative properties of many substances, and this he utilises for the restoration to health of those who are inclined to support him. Unfortunately there is only too much likelihood that this knowledge of simples is combined with the knowledge of poisons, which are used to enhance the respect paid to his priestly office and to assist in the removal of those members of the tribe who are likely to be obnoxious to him.

No small knowledge of surgery is often possessed by the "Medicine Man," and travellers have told wonderful tales of the operative dexterity of some of them, especially in Central Africa, but it is in dealing with wounds that the manipulative dexterity and medical knowledge of the "Medicine Man" are most conspicuously shown, and this is what might have been expected. In all early races war, whether defensive or offensive, is one of the most important occupations of the men of the community, and the rapid healing of wounds received in battle is of intense

value in maintaining the fighting strength of the tribe. Hunting also is one of the most important occupations of savage races, and injuries received in the chase must often need treatment.

The earliest knowledge that we possess of the practice of surgery amongst the Greeks is that given in Homer. Among the Greeks who had gone to Troy there were two physicians, Podalirius and Machaon. These were said to be the sons of Æsculapius, and that statement in itself is sufficient to cast great doubt on the existence even of these two men, but what is said about them helps us to understand the estimation in which physicians were held at this early date. Paris in the third battle wounds Machaon, and Nestor bears him rapidly away in his chariot from the battle-field towards the fleet. Idomeneus urges Nestor to carry Machaon away quickly, for he says—

> "A wise physician, skilled our wounds to heal,
> Is more than armies to the public weal."

The siege of Troy took place somewhere about 1100 B.C., and even if Homer's account is far from contemporary, it helps to establish the importance of medicine at a very early date. Arrows were the chief weapons of war then, and much skill is needed to remove an arrow safely from the body, as surgeons of the present time find who have to treat those wounded in fighting against savage races; for the barbs prevent the withdrawal of the arrow.

Much knowledge of the value of drugs was also possessed, as I have mentioned, by many women, and even in Homer we hear of Agamede, who was said

to know the virtue of every plant that grew on the earth.

In later times in Greece the practice of medicine was associated with the work of certain temples dedicated for the most part to Æsculapius, the God of Medicine. Each of these temples was situated in the neighbourhood of some mineral spring, which was of importance in the treatment employed.

To these temples repaired those who were suffering, and the priests treated them to the best of their ability, partly by hygienic measures, by exercise, by baths, and by draughts from the spring, partly by drugs, and even by operation. The grateful patients made offerings to Æsculapius for their recovery, and sometimes tablets were put up, setting forth the symptoms from which they had suffered and the means adopted for their relief. Some of these tablets still remain. These temples corresponded to modern spas and hospitals; for the most part they were situated in the healthy air of the country, generally near a medicinal spring, as mentioned above, and we may be sure that the pure air, the medicinal waters, and the simple diet contributed to the recovery of the patients. The most famous of all these temples was that situated in the Island of Cos in the Ægean Sea, where Hippocrates was born.

Rome owed its medicine to Greece. Most of the physicians practising medicine in Rome in the later republican times and in the earlier portion of the Empire appear to have been Greeks. Many of them were slaves, and some of them had been specially educated as doctors at the cost of their owners, so that they might be available at all times. Judging by the treatises which have been left to us, the physicians

of Rome attained to no small degree of skill both in medicine and in surgery. For the most part their knowledge of anatomy was very limited, and as it was not considered right to dissect the human body, they depended chiefly on the examination of the bodies of monkeys for their anatomy, for the resemblance to the human body was considered sufficiently close to justify conclusions based on them. In the Roman Empire for many centuries of the present era the practice of medicine degenerated for the most part into a slavish adherence to the teaching of the ancients, and the writings which we now possess consist mainly of commentaries on and amplifications of the texts of classical writers on medicine.

In the British Isles before the Norman Conquest it cannot be said that the practice of medicine had reached a high degree of development.

A little knowledge of the classical writers had filtered through, but for the most part medicine was based on tradition, and the virtues of herbs are recorded in several Anglo-Saxon manuscripts, in which, mixed with discourses as to the virtues of plants, are directions for the use of certain incantations. In Anglo-Saxon Herbals we find a curious blending of superstition and a knowledge of the properties of plants. It was supposed that bleeding could be stopped by saying certain words, and diseases were thought to be curable by the wearing of a precious stone or the foot of a hare. It was thought that the rarer a substance was, the more valuable it must be, and valuable not merely as estimated by the money it cost to obtain it, but by its effect in the treatment of disease. We find also that many substances which few nowadays would like to take as medicine

were then common ingredients of many prescriptions. Snails and ants and snakes were all considered of worth, as were also many other even less pleasant things.

Elaborate directions were sometimes given as to the conditions under which a plant was to be selected for the preparation of the medicine. In some cases a moonlight night must be chosen; in others an eclipse conferred value on a herb. The day of the week was also not without importance, and saints' days were of especial efficacy.

On the whole, medicine advanced more rapidly than surgery; gradually the knowledge of the properties of plants became more and more exact; gradually the recognition of the meaning of symptoms became more and more accurate; and we often cannot fail to wonder at the accuracy with which these old physicians interpreted the meaning of symptoms and prescribed for their relief. On the whole their descriptions of diseases are very brief, but here and there we can recognise the occurrence of diseases which have only been described with accuracy within recent years. During those centuries, which are often called the Dark Ages, the scientific study of medicine almost ceased in Europe, and only at Salerno in Italy did true medicine survive. It still existed amongst the Arabs, and moreover progressed, and even at the present day we possess a large number of treatises in Arabic, bearing witness to the care and assiduity with which the medical sciences were studied by them. Some, indeed, of these Arabic treatises were merely translations of Greek and Latin authors, but many of them were original. Rhazes, who is mentioned by Chaucer, and who lived in the tenth

century, was the first to give an account of "small-pox," though it is probable that the disease had existed ages before.

With the revival of learning, medicine also made a fresh start, and the most important factor in forwarding its progress was the increased study of anatomy, which then only really began. With the discovery of the circulation of the blood by Harvey a new impetus was given to the study of physiology, and indirectly this led greatly to the advance of medicine, for it enabled diseases of the heart and blood-vessels to be more thoroughly understood. The introduction of the microscope assisted greatly in the general advancement, for by its help the minute structures of the body became more clearly known.

I have sketched briefly the progress of European medicine from its early days in Greece to the present time, to show that medicine had a lowly origin, and that it reached its present height only after many centuries. Many a time during those long years progress has ceased, sometimes the science has retrograded, but after a time once again a step forward has been taken. We must not imagine that we are within sight of perfection in the practice of medicine ; our successors will surely perceive many faults in our methods, and mistakes in our practice, but we shall have done our part if we have striven to our utmost to advance even a little the science of medicine.

CHAPTER III

THE CAUSES OF DISEASE

It is very difficult, if not impossible, to lay down any precise definition of disease, and we may be content with saying that it is a deviation from health. Such a deviation may be caused by one or other of two conditions. Either it may be due to some bodily defect which has been inherited, or it may proceed from some cause coming from without. It is important to bear in mind that in many cases diseases which are said to be inherited have not existed in the child at birth, but they have affected the child because he has inherited a constitution which rendered him liable to be attacked by that disease; that is to say, he has inherited the predisposition to the disease but not the disease itself. Thus pulmonary phthisis, or "consumption" itself, is not inherited, but merely the predisposition to it.

Another classification of the causes of disease is based on their mode of action; they are divided into direct (or exciting) and indirect (or predisposing) causes. But this is not so simple a classification as might at first sight appear; for the very same condition may act according to circumstances in one case as a direct cause, in another indirectly. Simple examples of this may be found in cold and hunger. When cold is applied to a part of the body it may cause, as a direct effect of its application, definite

harm, such as frost-bite, or death from exposure may result as a direct effect if the whole body is subjected to severe cold, for the vital processes cannot go on unless a certain temperature is maintained. The effect of cold may, however, be indirect; it may weaken the tissues so as to make them more easily attacked by disease-germs such as those causing pneumonia. In the latter case the cooling of the body has made the tissues less able to withstand the assaults of bacteria, and so the cold has contributed to the disease; it has acted as a "predisposing" cause, but its action was not essential for the production of the pneumonia, for that disease may arise without the occurrence of any previous chilling. The bacteria of pneumonia are the essential element in the disease, and by them the disease has been started; the bacteria therefore form the "exciting" cause. Similarly, if sufficient food be not taken, the powers of resistance of the body will be materially lessened, and some diseases will more readily attack it, while if no food at all be taken, death may be the direct result of the want of food, as in death by starvation.

Until the "exciting causes" of disease were known the predisposing causes were looked upon as all-important; but when, with the advance of bacteriology, we became acquainted with the important part played by bacteria, it grew gradually to be the custom to ascribe the origin of the disease entirely to bacteria.

We have, however, learned, and in fact we are still learning, that bacteria in many cases are unable of themselves to give rise to disease in a person otherwise in perfect health, and that unless some additional factor is present, the disease will not appear. The

additional factor varies in nature in different cases, but it may be described in general terms as some impairment of the resisting powers of the body as a whole or of a special organ. This impairment may be temporary only, and dependent on some special cause, or it may endure throughout life. We know that bacteria may sometimes invade the body and yet not give rise to disease; the germs of pneumonia are often found in the throats of healthy people, and these germs do not, apparently, do any harm, until some change in the power of resistance of the lungs enables them to invade the lungs and give rise to pneumonia. Therefore we must be careful to estimate the germ at its true value, and not to think too much of its mere presence, while at the same time we must appreciate the very great importance of predisposing conditions.

In discussing the various causes of disease, it will be well to consider all causes, whether predisposing or exciting, and these may be conveniently divided into four groups :—

1. Mechanical causes.
2. Physical causes.
3. Chemical causes.
4. Parasitic causes.

1. Mechanical Causes

In the mechanical causes we include such forms of injury as cutting and stabbing, the wounds caused by a bullet, and the injuries brought about by falls. Little needs to be said of these. They do harm partly by shock and partly by tearing blood-vessels, or by injuring the nervous system. A few forms of

mechanical injury, however, deserve a fuller description. Concussion of any tissue may occur, the structure being shaken violently, but it is in reference especially to a form of injury to the brain that the term is used. A blow or fall on the head may produce one or more kinds of injury, but we are now considering only concussion. The brain is composed of a semi-soft material, and when it receives a sudden and violent shock many minute blood-vessels (or capillaries) are torn and small hæmorrhages occur into the substance of the brain, and these disturbances give rise to unconsciousness, which may be very slight and of but little importance, or it may lead to the most serious results.

Great changes in atmospheric pressure produce effects, partly as a result of the variation in the mechanical effect on the body and partly also in other ways. At great altitudes the diminution of pressure of the air on the surface of the body leads to some disturbance of the circulation, but the main harmful effects are due to a diminution of the amount of air taken in at each breath, and consequently to a deficiency in the amount of oxygen supplied to the tissues; it is probable that in some other ways also great heights do harm, but the matter is not completely settled yet.

Of more practical importance, at the present time, is the harmful effect of an increased pressure of air. This is seen to a small extent in those who work in diving bells, but it is most marked in those employed in "caissons." A "caisson," it may perhaps be advisable to explain, is a case or framework without a floor but closed in above; it is sunk into a river and it contains men who excavate the bed of the river.

In order to keep out water, air is pumped into the caisson, so as to produce a pressure which is greater than that exerted by the water. Roughly, it may be said, that for every two feet below the surface of the water the atmospheric pressure has to be increased by one pound on the square inch. Thus, at a depth of sixty feet, the natural atmospheric pressure would have to be increased by thirty pounds on the square inch. Each caisson has an "air lock," through which the workmen have to pass before they enter or leave the caisson. This "air lock" is a small air-tight room with two air-tight doors, one opening into the caisson and the other leading to the outer air. In each "air lock," as men prepare to enter the caisson the pressure is slowly increased to the pressure in the caisson, and as the men leave, the pressure in the "air lock" is slowly reduced to that of the atmosphere. The symptoms of "caisson disease" do not as a rule manifest themselves until after the workman has left off work for the day. The most common symptom is some form of paralysis. This appears to be produced by too sudden a reduction of pressure, which seems to cause gases to be given off in the liquids and tissues of the body, doing much damage. Fat especially appears to absorb a great deal of gas at the higher pressure. For the prevention of the disease it is advised that no workman who is stout should be employed in caissons, and more important still, the transition from the high pressure to the normal should be very slow.

2. Physical Causes

Heat and Cold.—One of the most important of the physical causes of disease is change of temperature.

The human body possesses a marvellous adaptability to heat and cold. It can endure the heat of the tropics and even higher temperatures; for men can survive after being submitted to a temperature of 260° Fahr., that is to say, nearly 50° above the boiling-point of water. This is possible because of the rapid evaporation of perspiration from the surface of the body; this evaporation has a twofold effect, for on the one hand, when the water of the perspiration is converted into vapour, a large quantity of heat is abstracted from the body, and on the other hand the layer of air immediately in contact with the body is also cooled, and this protects the skin, as air is a bad conductor of heat. Those people can endure high temperatures most easily who perspire most readily. If, however, the surrounding air is saturated with moisture no evaporation can take place, and as a result, a high temperature is much more unpleasant and harder to bear. Climates that are hot and dry, such as that of Australia, are much more endurable than those which are hot and moist, such as the climate of the tropical West Coast of Africa in the rainy season.

In the same way as man can endure very high temperatures, so also can he survive exposure to low temperature, even when the surrounding air is as cold as −70° Fahr., or 100° below the freezing-point of water; even at such a temperature as this life is possible. Here, also, the slight conducting power of the air makes it serve as a coating to the body, but if there is much wind, the heat is carried off more quickly and the temperature is less endurable. Both of these very high and very low temperatures can be borne only if the exposure to

them is not too protracted. When, however, heat or cold is applied to the body directly, as by a solid body, the temperature may be much less severe and yet prove very harmful. Burns and frost-bites both destroy the life of the tissues by killing the living cells. Burns and scalds differ only in that a burn is inflicted by a solid body and a scald by a hot liquid; the difference practically disappears when the heated liquid is one with a boiling-point much above that of water.

Light.—Light may, of itself, do harm to the body, though this is more likely to occur in tropical climates than in a country with the latitude of England. The pigmentation of the skin seen in the coloured races appears to have developed to prevent the harmful effect of excessive sunlight on the body. Though there is a certain amount of evidence that an excess of light has an injurious effect, yet we know little of how it acts. The X-rays are capable of producing severe inflammation of the skin and even of the deeper structures; and though we know little of the exact nature of the rays, we are now able to regulate their action so as to prevent any harmful effects. Radium has an action on the tissues in many respects resembling those produced by X-rays.

Electricity.—Severe injuries and deaths from lightning have been known as long as man has lived, and these cases exhibit the most startling harmful effects of electricity, but the wide extensions of the commercial and domestic uses of electricity have led to a number of deaths from it. The higher voltages are more dangerous, for death hardly ever occurs when the voltage is below 100, yet the fatal result depends not so much on the voltage, but chiefly on the passage

of a large quantity of electricity through the body, for the voltage may be exceedingly high and yet serious results may not be produced if the quantity is very small. The skin offers a great resistance to electricity, especially when quite dry; if the skin is wet its resistance is very little. This point is of importance in dealing with accidental leakages of electric current; it is far safer to touch electric wires with dry hands than with hands which are moist.

3. Chemical Causes

Some chemical substances harm the body by their direct caustic action on the tissues; this is seen in the effect of sulphuric acid or "vitriol," as it is often termed; it burns the skin and so destroys it. Another example of a substance with the same kind of action is quicklime.

Most chemical substances, whether poisonous or not, act indirectly after undergoing absorption into the blood, by which they are carried all over the body, and then they exert their action on certain tissues especially, for few, if any, chemical substances act on all the tissues of the body. Some act through the nervous system, some on the muscles, some on the heart or blood-vessels, and some on the organs connected with digestion, such as the liver.

At present we do not know why a chemical substance acts on one organ rather than another; though we can understand that if a poisonous substance is excreted by the skin it may have a special action on the skin.

A substance that may be present in food or drinking water in minute quantities, and when thus taken is harmless, may be definitely poisonous if administered in large doses; so that with all these chemical causes

of disease the quantity taken is of the first importance in determining the effect. Some of the chemical substances which harm the body are not taken in from outside, but are manufactured by the body itself. For instance, in some forms of indigestion or maldigestion of food, substances are formed which have a directly harmful effect on the body, and may give rise to diseases. Thus the poisonous substances that cause the symptoms of gout are not taken into the body in that form, but are made in the body itself by the action of abnormal vital and chemical processes.

4. Parasitic Causes

These fall naturally into two groups. First there are the larger parasites which are visible to the naked eye, some of which are vegetable in nature and some are animal. As examples of the larger animal parasites we may mention the tapeworm, the fluke, which is the cause of much illness among sheep, and the "trichina," which is the cause of "trichinosis." Some of these larger parasites do harm by absorbing nutriment from the body, some by destruction of the tissues, and some by producing chemical substances which act as poisons to the body.

The great importance of some of these larger parasites can be appreciated from an account of ankylostomiasis. The inhabitants of Egypt, Brazil, Burmah, and some parts of India are liable to a peculiar form of anæmia, which does not respond to ordinary methods of treatment and is at times fatal. The disease was known for many years before its cause was discovered, and it is now certain that this endemic anæmia is due to the presence, in the upper part of the intestine close to the stomach, of a small worm less than half an inch long. It is attached to the

lining membrane of the bowel, and it lives by sucking the blood of its host. It is called ankylostoma, and the disease is known as ankylostomiasis. The worm had been described long before its association with the endemic anæmia was recognised. Until recently there was no record of the disease occurring in cooler climates, but it is not rare in Italy, and when Italian labourers took part in making the St. Gothard Tunnel, the disease broke out there and was very prevalent. In mines it has appeared, even in the British Isles, and though the embryos are killed by frost, the temperature of many mines is sufficiently high, even in winter, to allow the disease to be persistent.

It is not certain how the animal obtains admission to the body, but it is probably through contaminated food, or perhaps through contaminated drinking water, though there is some evidence that it may enter through the unbroken skin.

Brickmakers are also liable to be infected, and in Egypt it occurs among the peasants working in damp earth. It is curious that many of the sufferers from this disease take pleasure in eating earth, and in this way the infection of the body is kept up even if this practice does not start the disease. The ankylostoma may exist in persons in apparently good health ; and it has been calculated that nearly three-quarters of the people in some districts in India possess this parasite. Suitable treatment, now that the cause is known, has been very successful in curing the condition.

The microscopic parasites are described in the chapter on Germs, and every year we are learning of fresh instances in which harm is done to the human body by some of these minute plants and animals. Fortunately the vast majority of the microbes known to us have no harmful effect on man, but the number

that can and do attack him is still very large, and were it not for certain powers of defence described in the chapter on Immunity, man would soon be exterminated.

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AN OPERATION ON THE LIVER

From a MS. of the Fourteenth Century

CHAPTER IV

GERMS

EVERY one nowadays knows that many of the most important diseases that affect the human race are due to minute living bodies, generally called germs, and the object of this chapter is to give an account of the nature and the mode of action of these little bodies.

Germs have many names; they are sometimes called microbes and sometimes micro-organisms, and to some special forms of them are given other names still, such as bacteria and bacilli. These germs are minute plants or animals, very low in the scale of life, in fact so low are they that it is sometimes difficult or even impossible to say with certainty whether some of them really belong to the animal or the vegetable kingdom. In some respects they resemble one, and in some points they resemble the other, but, for the most part, they belong to the vegetable kingdom, and therefore we look upon most of them as minute plants. In no way, however, do they resemble the plants with which we are commonly acquainted; for they have no roots, and no stem, and they do not flower.

The first idea that must be grasped with regard to these germs, is that they are exceedingly minute. With our ordinary ideas of size it is very difficult to appreciate any bodies so exceedingly small as most germs are. In the first place they are not visible to

the naked eye, and that fact itself shows they must be less than one five-hundredth ($\frac{1}{500}$) part of an inch in length, for that is about the limit of our unaided vision. One of the largest germs that may infect the human body is the anthrax bacillus, which causes the disease known as anthrax: it is liable to occur in this country amongst those who handle foreign hides, which are often infected with it. Even the anthrax bacillus measures only one eight-thousandth ($\frac{1}{8000}$) part of an inch in length; that is to say, if 8000 of these germs were placed end to end they would measure only one inch from one end to the other of the whole line. Now it is very difficult to appreciate so small a body as this, but, as I have said above, the anthrax bacillus is one of the largest of those causing disease, and the majority of germs are much smaller even than this. One of the smallest of those known is the germ that causes influenza, and this is only about one tenth the size of the bacillus of anthrax; that is to say, 80,000 of these germs placed end to end would only measure one inch. This germ of influenza represents nearly the limit of our vision at present by means of a microscope, and there are reasons for thinking that germs exist which are even more minute—in fact, so small that we cannot see them even with the highest powers of the microscope, and therefore as yet we cannot obtain any visual proof of their existence. It is, to say the least, very unlikely that the limit of minuteness of germs should practically coincide with our limit of vision by means of the microscope.

Up to now I have only spoken of the number of germs which could be put into an inch in length; the number increases enormously when we consider

an area of surface, while if we estimate the number which would be required to fill a certain volume, it is utterly inconceivable. For instance, a cubic inch could contain more than five hundred millions of millions of the influenza bacillus, or to express the same idea in another way, a single drop of liquid could contain several million germs.

Germs are no new creation; it is probable that they existed at a very early time in the history of the world; we have evidence that they were in existence at least as long ago as the carboniferous period, when the great coal measures were being formed, for, in the beds of coal, germs of various kinds have been found, and we are fully justified in thinking that they had existed for long ages before this. Even if we only date them from the time when coal was being formed they must have existed for millions of years.

Germs are very widely distributed. They are found everywhere on the surface of the earth except high up on lofty mountains. Everywhere in the air they are to be found except at great heights. All waters contain them, both fresh and salt; even in the sea far from land they may be found, though it is certain that they are far more plentiful nearer shore. All rivers, ponds, and lakes contain them, though in some waters they are far more numerous than in others. There are, however, some exceptions to this rule of their prevalence in all waters, for springs which rise from great depths, and the water from artesian wells, are practically always germ free. In the soil they are to be found even at a depth of many feet from the surface, but deep down in untouched ground and undisturbed rocks no living germs can be discovered. Although they are so

widely distributed they are not prevalent everywhere to the same degree. In some places they are scanty, in others exceedingly numerous, and it is especially in places inhabited by men or animals that they are most plentiful. For instance, in the air of the country there may be only one or two germs in each cubic inch, but if we take a cubic inch of the air of a town, especially in those parts which are most crowded, we may discover several hundreds of germs in every cubic inch of the air.

What are germs like? Germs vary enormously in shape and in size, but for the most part they are little rod-shaped bodies—that is to say, they have the form of little sticks. Some are rounded or oval like grapes or berries; some again are coiled into a spiral like a corkscrew; sometimes they form long strings, the germs being united together by their ends; and sometimes they form masses not unlike bunches of grapes. Germs differ from one another also in the power of movement. Some are absolutely immobile, that is, they cannot stir from the place where they are; others again are provided with means whereby they can swim about in a liquid and so make their way from one part of it to another; and this power of movement may easily be of importance in the production of disease. The minuteness of germs is remarkable, but even more remarkable is the rapidity with which they increase in number. The multiplication of germs is for the most part extremely simple. Each little rod grows in length until it measures about twice as long as at first, and then a transverse partition develops in the middle and two bacteria are thus formed. These may remain attached to one another more or less firmly, and so

form the long threads already mentioned, or they may separate. Sometimes germs have another method of increasing in number, which is employed when the external conditions are unfavourable for the life of the organism. This other method is by the formation of spores. These may be compared to the seeds of ordinary plants, and they seem to be formed chiefly when there is not enough food for the germs. The spores can remain a long time without food, and yet they may begin to grow when the conditions are once more favourable for them.

The rapidity with which germs increase may be very great. It is clear that if one germ can become two in a quarter of an hour, at the end of an hour it would have formed sixteen, at the end of three hours it would have formed more than 4000 germs; in ten hours the number formed would require, if this rate of production continued, more than twelve figures to represent it; while, if we estimate the number that could, theoretically, be formed in twenty-four hours we should reach a sum requiring dozens of figures; a number such as this is utterly beyond our comprehension. Of course this rate of production is not always maintained; some germs multiply quickly, and others take longer to increase in number. If food falls short, or if the temperature is too high or too low, then the increase in number is much reduced, and it may come to an end. I have, however, said enough to show that the marvellous power of multiplication possessed by germs must have important results if those germs are capable of harm.

It is especially in the power germs possess of offering resistance to unfavourable conditions that they

manifest the greatest difference from higher plants. A comparatively small change in the conditions prevailing in a country will often prevent a plant from growing well. A little increase or decrease in the humidity of a climate, or the occurrence of a few severe frosts, may put an end to the growth of some species of plants in a particular district where they may have lived and flourished for many years. It is, however, not so with germs; for the most part they possess a marvellous capability of withstanding adverse conditions, amply sufficient to destroy the vitality of higher plants. Even when the germs themselves are destroyed their spores may survive, and, awaiting favourable conditions, they may at length germinate and give rise to active forms.

Ordinary cold has no effect whatever on the vitality of germs. It is true that they become less active under the influence of cold; if they possess the power of movement their motility is reduced, and when the cold reaches the freezing-point of water, they cease to move at all. The power of multiplication also is in abeyance during exposure to low temperatures, but should the temperature rise again to one favourable to them the germs resume at once all their former powers exactly as if they had never been exposed to cold at all.

So far I have spoken of cold of ordinary degrees, but the results are practically identical when germs are exposed to temperatures far lower than that of the freezing-point of water. The most intense cold than we can produce appears to have little effect; for germs and their spores have been exposed for more than a week to the temperature of liquid air, that is, nearly 400° Fahr. below freezing-point, and

yet, when at the end of the time they were removed to a favourable temperature, they grew freely. The temperature of liquid air is an intensity of cold which probably never occurs naturally on the earth, in fact it may be described as twice as much colder than ice as ice is colder than boiling water. But we are able to produce, artificially, temperatures even colder than this. The temperature of liquid hydrogen, which is nearly 500° below freezing-point, did not affect the vitality of some germs which were exposed to it for ten hours. I have said above that the activity of germs diminishes as the temperature approaches the freezing-point of water, but certain bacteria have been found capable of growing on ice.

So much for the effect of cold. When we endeavour to try, by experiments, the effect of heat, we find that usually germs cease to grow when the temperature reaches 120° Fahr., and few can survive, if no spores are present, a temperature of 150° Fahr., and this is a higher temperature than the hand can bear. There are, however, some germs which flourish at a temperature higher than this, about 160° Fahr., and some of these are found living, growing, and multiplying in hot natural springs. These germs, which appear to enjoy these high temperatures, are called "thermophilous" or "heat-loving," and they are of no small importance, for they exist in, and in fact are the cause of, many natural fermentations in which there is an evolution of heat often reaching a high degree. An example of this may be seen in the heating of manure heaps which are utilised for forcing plants; it is also seen in the heating which is so likely to occur in haystacks, if the hay has not been thoroughly made: and if this is allowed to continue the temperature may rise

so high as to set fire to the stack. A similar heating is liable to occur amongst large masses of tobacco. These thermophilous bacteria flourish best at a high temperature, and in fact for every germ that exists there is a temperature which suits it best and at which it can grow most freely. This is called its "optimum" temperature. Most germs, however, are destroyed in a very few minutes in boiling water, but their spores, if present, are much more resistant, and prolonged boiling is necessary if an absolute freedom from living germs is required. The easiest mode of effecting this is to boil, on two or three occasions, at intervals of twenty-four hours; for after the first boiling most of the spores which have survived will have developed into bacteria before the second boiling, and so will be easily destroyed, and the third boiling will assuredly put an end to any which have escaped previously. This method of destroying germs by boiling is widely used in the modern practice of surgery, for it is essential that no germs should be present if the best results in surgery are to be obtained.

When dry heat is used to destroy germs it must be much more intense if the destruction of the germs and their spores is to be complete. It is suggested that the greater resisting power of spores is due to the fact that they contain less moisture than the germs themselves. A temperature of 400° Fahr. of dry heat will certainly render free from germs everything submitted to it. This baking of infected material is therefore looked upon as the safest method of destroying the contagion in infectious diseases such as scarlet fever or smallpox, and it is the method almost universally employed by municipal bodies to

carry out disinfection of clothes and bedding after cases of infectious illness.

Germs are but little affected by pressure; for no effect was apparently produced when some germs were submitted to pressures up to one ton on the square inch; when the pressure was removed they appeared to be none the worse for it. When, however, the pressure was increased greatly, so as to amount to some twenty tons on the square inch, many germs were destroyed, though even here some survived this terrible ordeal, and these survivors were chiefly spores.

Light, especially the light of the sun, has a truly wonderful effect on nearly all forms of germs. Almost without exception they are killed by a not very prolonged exposure to the rays of the sun, and the electric arc has a similar though, of course, less intense action. At first it was thought that the heat of the solar rays might be responsible for the death of the bacteria, but it has been shown by careful experiment that the rays of light themselves have a power of destroying germs quite apart from any heating effect which may be produced. This has been proved by interposing a bottle containing a liquid which does not allow the heat rays to pass through, though the light rays are unaffected. It has even been discovered which of the rays of light are most effective in destroying germs. All who have had anything to do with photography are aware that light rays of different colours have different powers of affecting the photographic plate. The violet rays at one end of the spectrum are much more effective in photography than are those which are nearer the red end of the spectrum; but even more

effective still in producing a photograph are those invisible rays which are beyond the violet rays and which are therefore spoken of as the ultra-violet rays. It is now known that the very same rays which are most effective in photography, namely, the violet and ultra-violet rays, are also those which have most power in destroying bacteria, while the rays near the red end of the spectrum have hardly any action on germs. This powerful action of the light of the sun in destroying germs is of enormous practical importance in Nature. Everywhere, when the sun is shining, in the air, in lakes, in rivers, and in the sea and on the land, all day long the light of the sun is destroying germs, and the action is fairly rapid. The knowledge of this fact helps us to understand one reason, at least, why rooms well lighted by windows are more likely to be free from disease than are those which are dark and gloomy.

Even when the light is not sufficiently bright to kill the germs, or its duration of exposure is not sufficiently long, much good may be done owing to the effect which the light has in weakening the powers of the microbes and thus in lessening their opportunities for harm. The fact that the electric arc lamp can be used for photography suggested that it should be employed for the destruction of germs, and there is no doubt that when the conditions are favourable, and the germs are not shielded by any intervening substances, the electric arc possesses a very definite power of destroying germs. These facts gave rise to the hope, a few years ago, that this power possessed by the electric arc lamp might be utilised for destroying harmful microbes in the human body, but up to the present it is generally agreed that it has

not been found possible to utilise the electric arc lamp in the direct treatment of microbic diseases.

Electricity has surprisingly little effect by itself. It is true that if an electric current be passed through a liquid in which living bacteria exist, numbers of them will die; but this fatal effect is not directly the result of the electric current, as it is brought about by the action of chemical substances to which the electric current has given rise. I do not suggest that electric currents are useless in the treatment of disease, for frequently they are of very great value, but that value, so far as we know, does not depend in any case on the direct effect of the electricity on any germs which may be present.

Many chemical substances have a very powerful effect on germs. Some of these chemical substances merely prevent the germs growing, without destroying them, but others have a direct action, killing the germs more or less quickly, and in this case, as in some others I have mentioned, it is found that the spores of the germs are much more resistant than the germs themselves. The value of chemical substances in destroying germs is now known to every one, and there are few who do not utilise the fact in some way or another. The use of antiseptic tooth powders and lotions for the purpose of keeping the mouth as free from germs as possible is very common. The value of vinegar for preserving some forms of food depends on its antiseptic action. Carbolic acid is widely used as a disinfectant.

Many microbes die when buried in the earth, but some have been found to survive many years; probably they survive longer when they are in the spore

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form. Nevertheless, though some germs are able to survive burial in the ground for years, many germs are rapidly destroyed by the action of the soil. Pasteur showed that the spores of the bacillus which causes anthrax were alive after they had been in a glass tube hermetically sealed for more than twenty years, but in this case they were subjected to no harmful influence.

Drying, if not carried very far, has but little permanent effect on many bacteria, though to others it proves rapidly fatal; and absolute desiccation seems to destroy all forms of germs.

If germs cause disease, how is it possible that any of us can survive when germs are as numerous and as widely spread as I have described above? Fortunately for us, all germs are not harmful. Of the many thousands of germs which are known to us, only a very small proportion can give rise to disease in the human body, while on the other hand, many germs are of the greatest importance in daily life. If it were not for germs, malt would never give rise to beer, and the juice of the grape would never become wine. If it were not for germs no cheese would ever ripen, and dough would never rise.

The special and much appreciated flavours of certain butters are said to be due to the presence of special germs. Vinegar is produced by the action of a particular kind of germ, and it would be easy to quote many more instances of the importance of the action of germs in daily life. When dead vegetable material is placed in the soil it cannot be utilised to make that soil more capable of producing plants until its structure has been changed by the action o'

certain germs which have this function. Every one interested in gardening knows the great value of a large supply of nitrogen compounds in the soil for the growth of crops; it is therefore of great interest to know that within recent years we have learned that there are certain microbes specially associated with, and growing in, the roots of peas and beans which possess the power of taking nitrogen from the air and combining it, so that it may be utilised for the growth of plants.

All germs give rise to certain chemical substances, and some of these are retained within the body of the microbe, and some are set free, and it is probably through the action of these chemical substances that germs produce many of the changes to which they give rise. I have so far spoken almost exclusively of germs which are vegetable in nature. There are a few which are really very low forms of animals, but these few animal germs produce some of the most important diseases in certain parts of the world. The best instance of a disease depending on an animal germ which I can quote is malaria. In this disease the minute animal, belonging to almost the lowest class of animals, obtains entrance into the body of the victim through the bite of a mosquito, and making its way through the blood it quickly enters a red corpuscle, in which it lives and multiplies, and which it ultimately destroys. Sleeping sickness, which has in the last few years attracted so much attention in Africa, is another instance of a disease caused by a germ which is animal in nature; and the tsetse fly disease, so fatal to many of the lower animals in certain districts of Africa, is another instance of the same kind. Fortunately the tsetse fly disease never

attacks human beings. At the present day we know much more about the importance of germs in the production of disease than was known even a few years ago, but it is not improbable that great additions will be made to our knowledge of this matter before many years pass by.

CHAPTER V

THE MICROSCOPE IN MEDICINE

THE unaided eye of the physician is incapable of recognising the minute structures of the organs of the body in health and the changes which those organs undergo in disease. Yet the knowledge supplied by the examination of healthy and diseased tissues has done as much as anything else to bring the medicine of the present day to the position to which it has now attained, and it is necessary for a due appreciation of modern medical methods that the use of the microscope as applied to medicine should be described.

The simple lens was a necessary prelude to the compound microscope. That simple lenses existed long ago there can be no doubt, though we have no direct knowledge of their existence. A convex lens of rock crystal was indeed discovered by Layard when digging among the ruins of the Palace of Nimrud, but the lens, if it be a lens, was very crudely made. Its surfaces were far from spherical, and it could have given but little assistance in the magnification of objects. We have, however, indirect evidence. The ancients were very expert in the art of gem-cutting, and much of this work is so minute that it is almost impossible to believe that it was carried out without the assistance of a magnifying glass. We may take it therefore as practically certain

that at the time when the art of gem-cutting attained perfection lenses were known. In Europe convex lenses appear to have been employed for more than 600 years in the form of spectacles, and though spectacles of native manufacture are widely used in China, there is, I believe, no evidence that they were invented before they appeared in Europe. The practice of making lenses for spectacles soon led to such good results that when the telescope was invented it was an easy matter to obtain the lenses suited for it. The invention of the compound microscope was more difficult, for the object glass required a lens of high curvature, such as were never required for spectacles. At first glass globules made by melting threads of spun glass were employed, but their surfaces were not perfectly regular, and the results were poor.

The celebrated Dutch observer, Leeuwenhoek, was the first to succeed in making simple lenses of very high curvature and with short focus, and though these were inferior in power of magnification to the compound microscope of that day, the picture was much clearer. For practical utility clearness of the image is of very much greater importance than merely great magnification. Leeuwenhoek was born in 1632 at Delft, where he worked as a lens grinder. He was very successful in grinding lenses of very short focus, and with these he was able to make several discoveries of no little merit in minute anatomy. His chief discovery was certainly that of the minute blood-vessels called capillaries and of the circulation of the blood through them. Harvey had perceived from the facts which induced him to believe in the circulation of the blood that there must be some minute communica-

tions invisible to the naked eye between the smallest arteries and the smallest veins. Leeuwenhoek's discovery, which was published in 1690, supplied just that step which was wanting for completing the proof of Harvey's doctrine of the circulation of the blood.

After several failures to see the capillary circulation in the comb of a fowl and the membrane of a bat's wing, he succeeded ultimately with the tail of a young tadpole. He says: "I could distinctly perceive the whole circuit of the blood in its passage to the extremities of the vessels, and in its return toward the heart." Malpighi had indeed discovered the red corpuscles a little before this, but Leeuwenhoek saw them more clearly, and recognised that in man they were round, flattened discs, while in the frog they were oval. It was by the movements of the red corpuscles that he was able to perceive the blood circulating. By the aid of his lenses he made many discoveries; he recognised the structure of the skin, of the teeth, and of other parts of the human body, and his researches in the minute anatomy of the lower animals and of plants were of great importance. His accounts of what he could see were not always accepted by his contemporaries, for apparently he could see more minute structures than others could see, even when using the same lenses. To Leeuwenhoek must certainly be given the credit of being the first great worker with the microscope, even though he employed, not the compound microscope, but the simple lens.

In the compound microscope in its simplest form two convex lenses are placed in such positions that the one near the eye can magnify the image formed by the other. The lens towards the object is called

the object glass, and the lens towards the observer's eye is called the eyepiece. The inventor of it appears to have been Zansz, a spectacle maker of Middleburg in Holland, about the year 1590. For a long time its faults were many and the images it formed were not at all clear. The two chief faults were spherical aberration and chromatic aberration. Owing to spherical aberration the image formed is not distinct; and owing to chromatic aberration the image is irregularly tinted with various colours. These objections were removed partly by the work of Dollond and partly by Tulley, and it is worthy of note that Mr. J. J. Lister, the father of Lord Lister, assisted in perfecting the compound microscope, especially with regard to the improvement of the achromatic object glass. These improvements consisted mainly in making lenses of several pieces of different kinds of glass, so that the errors belonging to one piece corrected the errors of another.

This was in 1830, and since that time progress has continued, until now microscopes are manufactured both by British and foreign makers which give wonderful results. The demands made on the microscope are increasing, and we appear almost to have reached the limit of progress of which the microscope is capable along its present lines. Doubtless in the future some new method will be devised to increase the capabilities of the microscope.

We have traced thus far the microscope from its simple beginnings to the present very complex and accurate instrument, and now I will describe some of the ways in which the microscope is used for the study of disease.

As the blood was the first object that engaged the

microscope in the study of the structure of the body, I will begin with an account of the way in which the microscope can assist in our study of the changes in the blood occurring in disease. The simplest use to which the microscope can be put in connection with the blood is to count the corpuscles. In health there are about five million red corpuscles in a cubic millimetre of the blood of a man, and about half a million less in the same quantity of the blood of a woman. In ordinary anæmia the red corpuscles are reduced in number, and we can form a more exact estimate both of the degree of anæmia present and of the effect of the treatment employed, if we know the number of red corpuscles present. In some cases of simple anæmia the number of red corpuscles may be greatly reduced, so that there are found to be in a cubic millimetre only about two million or even a smaller number than this. Sometimes in anæmia there is very little diminution in the number of red corpuscles, but each red corpuscle contains a smaller amount of hæmoglobin—the red colouring matter of the blood, than it should. The result, so far as the symptoms are concerned, is the same. There will be less power of absorbing oxygen from the lungs and carrying it to the different parts of the body, and therefore shortness of breath will result.

It is clear that simple anæmia may result from many causes. It exists for a time after any severe injury or operation in which a large amount of blood has been lost ; it may follow insufficient or unsuitable food, or it may be merely one manifestation of a disease. Iron is an essential constituent of the hæmoglobin, and in many cases in which there is deficiency of hæmoglobin, iron is often prescribed and proves

useful. It is probable, however, that in many cases there is no lack of iron in the food, but for some reason the body cannot assimilate it; for the total quantity of iron in the body is not great, and it has been estimated at only a few grains. There is another form of anæmia called pernicious anæmia, which is a more serious malady; but it is probable that under this name are included several distinct diseases. In the chapter on the causes of disease I have mentioned that a worm—the ankylostoma—may produce a very severe form of anæmia, and this at one time was looked upon as a form of pernicious anæmia. In this disease not only is the number of corpuscles diminished—and it may fall to half a million or even to two hundred thousand in the cubic millimetre—but many of the red corpuscles have unusual shapes. It will be seen, therefore, that the examination of the blood and the enumeration of the red corpuscles may be of great importance. I will now give a short account of the method employed for counting the corpuscles of the blood.

It would be hopeless to attempt to count the corpuscles of the blood as it is drawn from the body, for it contains so many corpuscles that they cannot all be visible at once, even if a very thin layer be taken. Therefore, the blood has to be diluted. The lobe of the ear or the ball of a finger is pricked with a clean sharp needle, and a small quantity of the blood is drawn up into a narrow tube of known volume. When sufficient has passed into the tube reaching to a certain mark, this amount of blood is thoroughly mixed with two hundred times its volume of a liquid which prevents clotting, and then a minute drop of this is placed on to a microscopic glass slide,

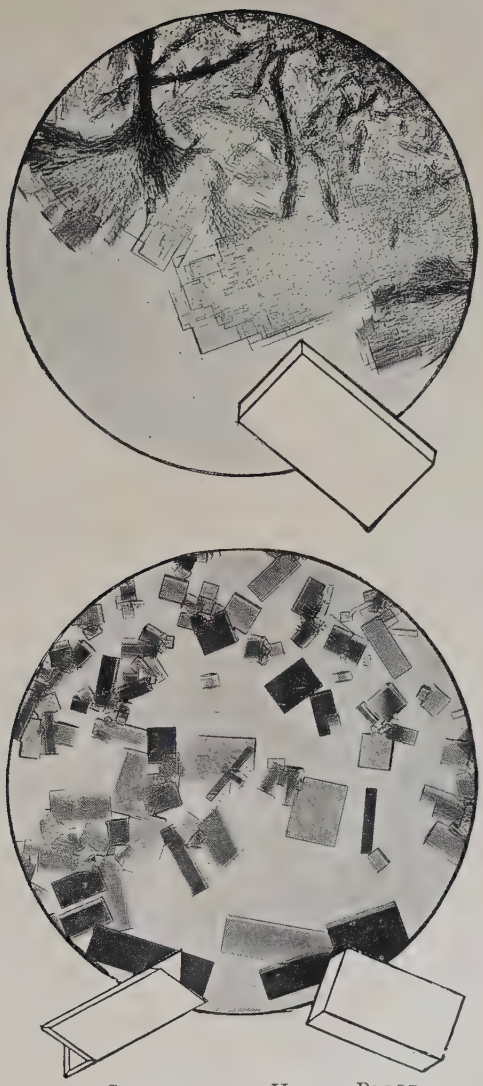
on which is a "counting cell." This cell consists of a glass ring, one tenth of a millimetre high, cemented to the glass slide. The space enclosed is divided by fine lines into squares, such that the volume marked out by each square is equal to $\frac{1}{4000}$ of a cubic millimetre. The drop is covered with a piece of extremely thin glass. When the corpuscles have had time to settle, the slide is examined under the microscope, and then the observer is able to count the number of red corpuscles in each small square. If this number is multiplied by 4000 and then by 200 (the degree of dilution), we obtain a result showing the number of red corpuscles in a cubic millimetre. Greater accuracy would be obtained if the observer counts the number in ten squares and divides the total by ten, before multiplying by 4000 and by 200.

To take an example: ten squares are counted and it is found that in the ten squares there are 45 red corpuscles; this, divided by 10, will give an average of $4\frac{1}{2}$ in each square. If $4\frac{1}{2}$ be multiplied by 4000 and then by 200, we obtain 3,600,000 as the number of red corpuscles in a cubic millimetre.

It is clear that the larger the number of cells counted the more accurate will be the result.

Similarly the white corpuscles may be counted, and at one time that was considered sufficient. But now it is known that there are several kinds of white corpuscles, and for diagnostic purposes it is necessary to know how many of each kind are present. These different forms of white corpuscles can be best distinguished if they have been stained, and for this purpose a "film" preparation has to be made.

A very thin layer of blood is spread out on a cover glass and dried. The film can then be stained, and



A. Crystals from Human Blood

It is often possible to identify the source of blood by means of crystals which can be obtained from it, for each race of animal has its own special form of blood crystal. The large crystal at the margin exhibits the typical shape.

B. Crystals from the Blood of the Baboon

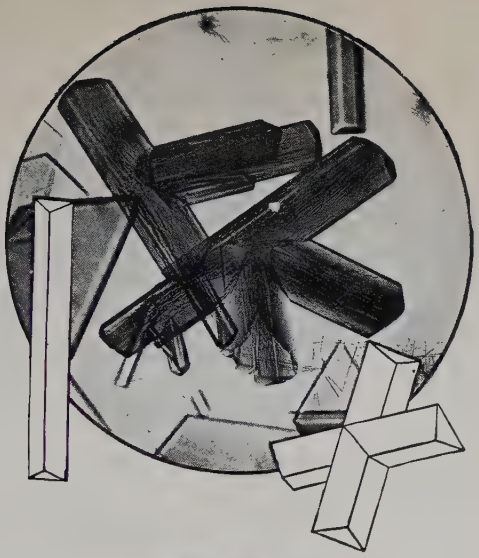
These show some resemblance to crystals from human blood.

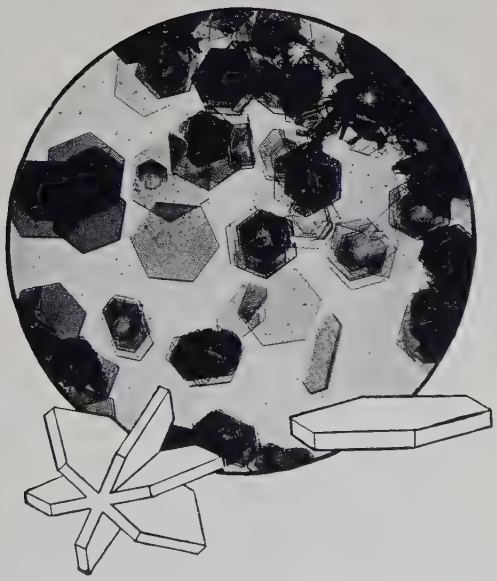
when the cover glass has been suitably mounted, the white corpuscles can be examined and their relative proportions ascertained. It may be asked what is the use of knowing the proportions of the different kinds of white cells. The matter is much too complex to describe, but as an example of the kind of information which may be obtained from a "differential blood-count," as it is called, we can usually distinguish the anæmia which is due to a parasite such as the ankylostoma from other forms of anæmia by the fact that the blood contains a larger number than in health of white corpuscles, which stain readily with a dye called eosin.

The amount of hæmoglobin also often needs estimation, and though this does not require the use of the microscope, it may well be described in this chapter in connection with the other methods of examining blood. The principle of the different methods is always the same, and it consists in comparing a diluted specimen of the blood with certain standard tints which correspond to definite percentages of hæmoglobin. This estimation is always of importance in connection with counting the number of red corpuscles.

Within the last few years the estimation of the time which the blood takes to coagulate is also a matter of some importance. In the disease called Hæmophilia, occurring chiefly in boys, there is a very great tendency to bleed, the slightest cut continuing to bleed for a long time after it should have stopped. Extracting a tooth in these patients ("bleeders," as they are called) is often followed by hæmorrhage which does not cease spontaneously, and can only be made to stop with the greatest trouble. Hæmophilia occurs

in families, and when its presence has been recognised, no operation, even the slightest, should be performed unless it is absolutely essential to life. In these boys it has been found that the coagulation time of the blood is much increased. There are several methods of ascertaining the time taken for coagulation, and the simplest is to have a series of fine capillary tubes filled with blood, and to determine when clotting begins by blowing the contents of a tube on to a piece of filter paper at intervals, say, of a minute.





C. Crystals from the Blood of the Horse

D. Crystals from the Blood of the Squirrel

These are six-sided plates, of a shape often used for tiles.

CHAPTER VI

THE MICROSCOPE IN MEDICINE (*continued*)

Bacteriology

In the chapter on Germs a general account was given of these minute organisms, but little was said as to the practical details of recognising the different varieties. In this chapter will be found a description of the science of bacteriology as applied to medicine.

The number of germs known is very large, but only some of these affect the human body, and therefore it is with these we are chiefly concerned. Even in health many germs are present; on the surface of the body are to be found large numbers of micro-organisms of several kinds, and some occur so regularly that it may almost be said they are normal inhabitants of the human skin; they are not completely removed by ordinary washing, and special precautions require to be taken if it is wished to obtain any part of the skin perfectly free from them.

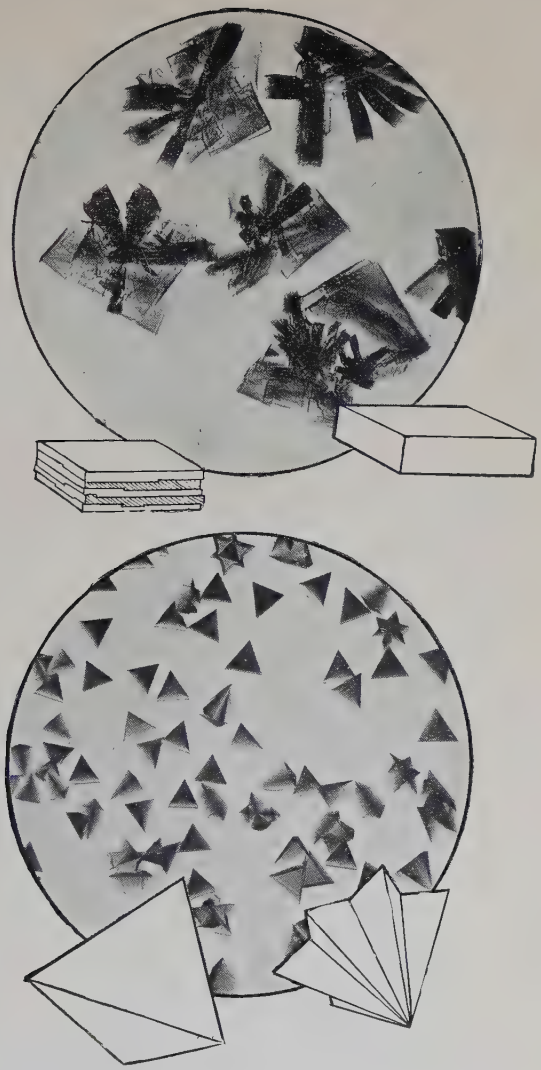
In the mouth also may be found, even in perfect health, many varieties of bacteria. It is clear, therefore, that the mere presence of an organism in the body cannot be taken as a proof that the body is suffering from disease caused by that organism. In the mouth in health can often be found the germ that causes pneumonia, and on the surface of the skin can usually be discovered those which give rise

to boils and abscesses. Part of this absence of disease, in spite of the presence of the organism, is doubtless to be ascribed to one or more of those protective influences which will be found mentioned in the chapter on Immunity; and if the tissues are healthy the germ is unable to grow freely, and awaits the time when, by some local damage, or in some other way, the tissues will become vulnerable to its attacks.

If, then, the patient is suffering from some disease which we believe to be microbic in origin, how will the bacteriologist proceed in order to settle the question?

In the first place he will endeavour to examine microscopically some of the fluid of the part affected. If there is a secretion from the nose which is suspected to be the result of a micro-organism, he will take a small quantity of it and make a "film preparation" as described in the chapter on the "Microscopic Examination of the Blood." This film is extremely thin, and it is dried so as to fix it firmly to the glass slide on which it is made. It can then be stained in the manner which is most likely to show what is looked for, or several films can be made, and a different method of staining applied to each.

In this way it may be seen that some organisms are present in small or large numbers, which can readily be recognised at sight, and stained with a suitable dye. On the other hand it is not improbable that the smear may only show a few micro-organisms which are not possessed of characters sufficiently definite to enable them to be recognised. In that case it will be necessary to make a "culture," or even, if the "smear preparation" gives us fairly certain



E. Crystals from the Blood of the Goose

The blood crystals of birds show as great differences between the various species as do the crystals of mammals.

F. Crystals from the Blood of the Guinea Pig

These blood crystals are mainly three-sided pyramids.

information, a culture may serve to confirm this. A "culture" has several uses; sometimes, although the individual micro-organism, as seen through the microscope, may look very much like other micro-organisms, yet when it is grown in a culture it may exhibit characteristics which serve to differentiate it. Secondly, by means of a culture it is possible to obtain a very large number of the germs and to study them fully, and the mere fact that an organism requires certain conditions to be observed before it grows in a culture, will often afford us valuable information as to its identity. Lastly, a culture is one of the necessary steps in the preparation of a "vaccine," as described in the chapter on Immunity.

By a "culture" is meant a cultivation of a micro-organism in a certain material which is suitable to its growth. This is called the "culture medium." Some culture media are liquid, such as broth (made of various meats, either unmixed or containing other substances), milk, the serum of blood, and some artificial liquids, especially Pasteur's Fluid. Most culture media are, however, solid: a preparation of gelatine called nutrient gelatine is very convenient, but it is liable to liquefy in very hot weather, or if incubated at a high temperature. Agar-agar is convenient; this is a preparation of "Ceylon moss," and has the merit of remaining solid at all temperatures. There are various forms of Agar-agar, according to the substances which are mixed with it, such as maltose agar when mixed with a form of sugar. Potato is sometimes a convenient medium. These culture media are kept in glass vessels of various kinds. The commonest form is a test-tube such as is used in chemical work, and in it the culture is placed and

the mouth is closed with a plug of cotton-wool; and it has been shown by experiment that this cotton-wool is quite capable of preventing germs from outside entering the tube. Both before being placed together, and after, the culture medium, the test-tube, and the cotton-wool are sterilised, and they are then usually tested by being kept at a suitable temperature to see if any micro-organism will grow in the tube. If any growth does appear, that tube was evidently not aseptic, and it is rejected.

When a tube has been proved to be free from germs by this test, it is necessary to inoculate it with the germ we wish to grow. If it is a germ whose likes and dislikes we do not know, it is generally advisable to take several culture tubes containing different media, and these are all inoculated, so that we shall probably be able to obtain at least one satisfactory culture. In inoculating a tube it is essential to take the utmost care that micro-organisms other than those we are interested in do not gain access to the test-tube. To transfer the germs to the test-tube a platinum loop is generally employed. This is made of a piece of platinum wire fixed in a glass rod; and the end of the wire is turned back so as to form a loop; and first of all a good portion of the wire is held in a flame of a Bunsen burner or a spirit lamp, until it is red-hot. That method ensures the destruction of any germs that were previously on it.

Then the platinum loop is made to touch the surface from which the germs are to be taken, and a small quantity of the fluid is transferred to the test-tube, and deposited on the surface or in the interior of the culture medium. For this purpose the cotton plug at the mouth of the test-tube is taken out and re-

placed as rapidly as possible so as not to allow any extraneous micro-organisms to gain entrance. The test-tube, thus inoculated, has to be kept at a uniform temperature suitable to the organism present. The majority of germs harmful to the human body grow best at the temperature of the body, that is, a little below 100 degrees Fahrenheit. However, others require a lower temperature, and about 70 degrees Fahrenheit is convenient. To maintain the culture tubes at either of these temperatures an "incubator" is required, which resembles in many respects the incubator used for the hatching of eggs, and like it possesses an automatic arrangement which, by controlling the supply of gas, maintains the temperature at a uniform level. After a time, in some of the tubes, if the conditions, such as the nature of the culture medium, and the temperature of the incubator, have been favourable, a spot or mark will appear on the surface of the medium showing that the growth of some germ has commenced. It often happens that the naked-eye appearances of this growth are sufficient to enable the bacteriologist to come to a trustworthy decision as to the nature of the organism present. For the characters of the growths vary; the colour is often of value; the way in which it spreads is also of importance, and sometimes the appearance of bubbles of gas or the liquefaction of the medium will provide clues to the identification of the microbe. Often, however, it will be necessary to remove the organism from the medium, and to examine it microscopically with or without staining before arriving at a conclusion as to its nature.

When several tubes containing different media have been inoculated at the same time, it is prob-

able that only some of them will manifest any growth.

Not infrequently it will happen that the drop of fluid which the loop of platinum wire has implanted on the medium contains, not only one organism, but two or even more. In such a case the growths in the culture tubes may show that more than one organism is present, because two growths of obviously different appearance manifest themselves. Hence it will be possible for the bacteriologist from such a tube to inoculate a fresh tube with one or other of the organisms present according as he may wish. Even when two germs have been inoculated in the tube it does not necessarily follow that both will grow, for the conditions may be favourable to one and unfavourable to the other.

In the chapter on Immunity will be found a description of the preparation of vaccines from any special germ, and I have there explained that a vaccine prepared from the patient himself is often more efficacious than a "stock" vaccine, that is to say, one which is kept ready-made.

Bacteriology is sometimes of very great importance in diagnosis. I will give an instance. Diphtheria is a disease due to a germ called the diphtheria bacillus, and it manifests its presence by the appearance of patches of "false membrane" generally on the tonsils or palate. In some cases it is easy to recognise diphtheria by the naked-eye appearances of the patches in the throat, but many doubtful cases occur, and it is useful or even necessary to utilise the bacteriological test. A swabbing from the throat of the patient is rubbed over the surface of some blood-serum in a test-tube. This is then incubated at a

temperature just under 100 degrees Fahrenheit for eighteen to twenty hours, and the growth is then examined microscopically, after it has been stained, and then it is easy to recognise the germ. The diphtheria bacillus is a good example of the effect of a culture medium on the characters of the bacillus. In broth the diphtheria bacillus is short and stunted; on blood-serum and on gelatine it is of medium length; while on glycerin-agar it is very large. It is best stained with a special dye of methylene blue.

In doubtful cases, especially in those which are mild, this method of diagnosing diphtheria is of very definite assistance. Now these doubtful and slight cases are the most dangerous, because the patient is not ill enough to be in bed, but he is quite well enough to go about and infect others. Therefore, in all doubtful cases, in fact in any case in which there is the least doubt, the diphtheria bacillus should be looked for bacteriologically, and this method of examination is also of great value in deciding the question whether and when it is safe for the patient to mix with others. So long as the special bacilli can be found in the throat by this method of examination, so long is it clear that infection of others is possible; therefore a child who has had diphtheria should not be allowed to mix with his fellows until the bacteriologist reports that by this test no bacilli have been found to be present. Usually it takes about three weeks for the diphtheria bacilli to disappear from the throat, but sometimes they remain much longer than this, even for months. It is clear that while a positive result of the bacteriological test of the presence of diphtheria bacilli is of the greatest value, a negative result is worth much less, for the

swab may have failed to bring any out though they were present; therefore sometimes if the test is negative it may need to be repeated.

A bacteriological test known as "Widal's Reaction" is of great value in the diagnosis of typhoid or enteric fever. A few drops of blood are taken from the ear or finger of the patient and are drawn into a capillary tube and sealed, so as to be ready for the test. A recent culture of the typhoid bacillus in broth is employed, and ten drops of it are taken and mixed with one drop of the serum of the patient. The mixture is then examined under the microscope for half-an-hour. The typhoid bacilli which were moving freely before, become quickly still when mixed with the patient's serum. In a few minutes the bacilli begin to mass together into clumps, and by the end of half-an-hour the clumping is complete. If the clumping occurs it is almost certain proof that the patient is suffering from typhoid fever, but the test certainly fails sometimes even though typhoid fever is present.

Bacteriology is of immense value in controlling the water supply of a town. The chemical examination of drinking water will give us much information as to contamination with sewage, but it tells us nothing as to whether the germs of disease like typhoid are present or not.

The bacteriological examination is of the greatest possible importance in this respect.

In examining a specimen of water for its bacterial constituents, a specimen is taken in an aseptic bottle. It is important that it should be examined as quickly as possible, for if it is allowed to stand for long the number of bacteria present may increase greatly, and

forty-eight hours of delay may make a difference of many thousands in the number of bacteria present. If it is quite impossible to examine the specimen within a short time of its being taken, it should be kept in ice, for the cold will practically prevent the multiplication of the germs. To find the number of organisms present, four culture tubes containing gelatine are taken, and they are inoculated with different measured quantities of water. After the water and the gelatine have been mixed together the contents of each tube is poured out into a flat, shallow dish, called a "Petri dish," which has a glass cover to protect it from extraneous organisms. These dishes are incubated at a temperature of 70 degrees Fahrenheit for a week, and at the end of that time they are examined. Every germ which has developed will have formed a little colony visible to the naked eye, and if these colonies are counted, it is easy to calculate the number of germs present in any volume of water. If only a few germs were present in the water, it will be easy to count them in that specimen to which the larger quantity of water has been added, but if many germs were present this specimen might show so many colonies that it might not be possible to count them, and therefore a specimen with a smaller quantity of water might give more satisfactory results.

If a cubic centimetre of the water contains not more than five hundred organisms it may be described as fairly good. A very good water indeed will contain less than one hundred.

If it is desired to look for any special organism, special methods would have to be employed for that purpose.

Although the number of organisms present cannot be a certain guide as to the value of the water for drinking purposes, yet it affords valuable assistance in estimating the fitness of the water for drinking. The filtration of water to serve for the supply of a town is generally carried out by means of a sand filter bed. This works much better after a short time than at first, and it has been found that the real filtering medium is a layer of mud which gets deposited in the interstices of the sand. When a new filter bed is freshly made the effluent contains many more micro-organisms than it will contain a fortnight later.

The most remarkable discovery that has been made in recent years in connection with the water supply of towns is the diminution in the bacterial element in water on keeping. When water is allowed to flow into a reservoir and there remain still, the number of bacteria in it steadily decreases, so that after a few weeks it has become a much more suitable water for drinking purposes than at first. This fact renders it very desirable that there should be several large reservoirs in connection with the water supply of towns, so that it would not be necessary to use the water until after it had stood for several weeks.

CHAPTER VII

THE MICROSCOPE IN MEDICINE (*concluded*)

Microscopic Examination of Tissues and Tumours

It is possible in some cases to recognise the nature of a tumour by the naked eye, so that the surgeon can be certain that it is harmless, but this he cannot always do. Many tumours are so much alike when examined by the unaided vision that a satisfactory conclusion can rarely be based on what has been seen, therefore it becomes necessary to employ a more certain method of investigation.

To use the microscope in the examination of solid substances like the tissues, it is necessary that they should be in very thin sections; otherwise they are not translucent and cannot be clearly examined. Most tissues are too soft as they are taken from the body for sections to be made from them, and therefore it is necessary to make them firmer, or to "harden" them as it is called. They must not be made too hard, otherwise the knife will not be able to cut a very thin section. Many liquids are used for hardening, such as alcohol and a solution of chromic acid, different reagents being employed according to the tissue which is to be examined. These hardening reagents also serve as antiseptics and prevent decomposition. A piece of the tissue is taken; it must not

be too big or it will not harden well, a piece about three-quarters of an inch in diameter is a common size, and it is put into the hardening fluid. After immersion in one or more of these liquids for a longer or shorter period as experience has shown to be necessary, the small mass of tissue is ready to be cut into sections; but before this can be done it must be fixed firmly, or embedded, as it is called, so that it may be held firmly before the section knife is applied to it.

The simplest and quickest method is to freeze the mass of tissue after surrounding it with gum. Sometimes it is necessary for the surgeon to learn the nature of a tumour in the middle of an operation so that he may know the best course to pursue. The freezing method is therefore especially useful in these circumstances, as it takes so little time. By the freezing method perfectly fresh tissues can be cut without undergoing any previous hardening. Though this method is very quick, and therefore may be used when time is of importance, the results on the whole are not so satisfactory as when another method is employed. In this second method the tissue is placed in the middle of melted white paraffin, such as paraffin candles are made of, or any other similar substance may be employed. When the paraffin has become quite cool and solid the section cutting may begin. For cutting sections many instruments have been invented, but in principle they are all the same. A very sharp razor is brought across the mass of tissue, and each time it passes, the tissue is raised a very short distance by means of a fine screw so that extremely thin slices of the tissue are cut. In some instruments the knife moves; in others the knife is

fixed, and the tissue is brought to it for each section. In this way sections can be cut less than the thousandth of an inch in thickness. Even when satisfactory sections have been cut, it is not possible to learn much from them by the microscope in their present state, and they require staining.

I have already said that we distinguish the different kinds of white corpuscles by the different ways in which they receive stains; it is in the same way that we are able to distinguish different tissues from one another. Various stains are employed; most of them are made from aniline dyes. A little of the stain is put into a watch-glass or other shallow dish, and one or more of the sections are immersed in the liquid for a longer or shorter time. In this way certain tissues seize certain stains, while others are affected by other dyes. It is necessary to employ other solutions for fixing the stain in the tissues and for making them more transparent or "clearing" them. When the staining and clearing are complete, the section is carefully spread out on a microscopic slide and then on it is placed a drop of some form of cementing substance, and over it is placed a very thin piece of glass, called a "cover glass."

The section is then ready for examination under a microscope. Now the structure of the tissue can be seen. The cells and fibres of which it is composed are clearly discernible, and by the colours with which the different portions of it have been stained we can tell something of their chemical composition. For instance, if osmic acid has been employed in the stain, any fatty substance present will be coloured black. In this way it is possible to obtain,

in most cases, a very exact idea of the structure and nature of the tissue examined.

If it is thought that bacteria are present in the tissue and it is desired to examine them, it will be necessary to employ stains which will colour them; and in this way also we can distinguish different bacteria. In the tissues many bacteria show little difference in appearance. Occasionally by the size or the shape of a microbe we can recognise it, but more commonly we have to employ certain stains to assist us in the recognition of the germs. Some bacteria will take a particular stain while others will not.

It is sometimes convenient not only to stain the bacteria but also to stain with a different colour the tissues in which the bacteria lie. This will generally give very striking effects, and it makes the bacteria much more visible.

Fresh stains are frequently introduced giving results which could not be obtained before, and helping us to know with greater certainty the nature of the tissues examined.

In 1889 influenza reappeared in Great Britain for the first time for forty years. When it was prevalent before, bacteriology as a science did not exist, and therefore nothing was known as to its bacteria. On its return film preparations were made, but none of the stains then employed showed any special organisms, but the slides were put aside. The next year Pfeiffer found a stain that showed the bacillus of influenza, and when this stain was tried on the slides which had been prepared in the previous year, the bacillus was readily seen.

CHAPTER VIII

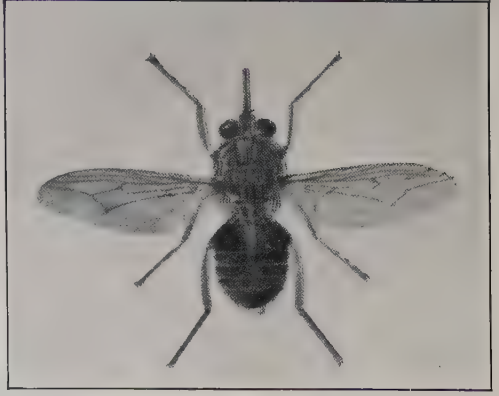
IMMUNITY

It is well known that many infectious diseases which attack one class of animal may not have the least effect on animals belonging to other species. Most of the infectious diseases to which man is liable do not appear to be communicable to the lower animals; it is also true that most of the infectious diseases to which races of the lower animals, such as cattle, sheep, or dogs are subject, do not attack human beings. When the most virulent pestilences have been raging through large communities, as a rule none of the domestic animals have shown any sign of being affected. Neither scarlet fever nor measles has been known to invade any of the animals which come in contact with man. When, in 1897, the rinderpest was killing hundreds of thousands of cattle in South Africa, not a single human being showed at any time the slightest trace of an attack of the malady. In those regions of Africa where the tsetse fly disease attacks all horses except those which are "salted," that is, those which have already had an attack of the disease, man is not affected. The rule that human beings and animals are not attacked by the same infectious disease is by no means absolute, and as an instance it may be mentioned that rats suffer greatly during an epidemic of plague.

This freedom from liability to catch a disease is

called "immunity," and it is of two kinds. The form of immunity with which a person is born is called "inherited immunity," and it is that form which I have described above, and which is possessed by all the members of a race.

There is, in addition, another form of immunity. When a man has had an attack of scarlet fever, there is no real risk that he will take it again, however much he may be exposed to infection. I cannot say that infection in such a case *never* occurs, for instances are occasionally reported in which a person who has had one attack of scarlet fever is said to have a second attack. It is probable that in some of these cases an error of diagnosis has been made, but there are certainly some, a few, a very few cases, in which a second attack of scarlet fever occurs. Nevertheless, the general law holds good that for all practical purposes a person who has had one attack of scarlet fever cannot be reinfected, and this is true also of most of the other acute infectious diseases. This freedom from liability to contract a disease, possessed by those who have suffered from it, is another form of immunity, and it is called "acquired immunity." This fact that an attack of most of the acute infectious diseases affords protection against a second attack has been recognised everywhere for many centuries, and attempts have been made to utilise it. Inasmuch as many of these diseases attack more easily those who are weak and out of health, it was thought that if the disease could be given when the patient was in good health the attack would in all probability be milder, and less likely to prove fatal. This method was used for smallpox, and it was called "inoculation." Though



TSETSE FLY

Which carries the germ of sleeping sickness, and communicates it to man.

MOSQUITO (FEMALE) OF MALARIA (ANOPHELES)

Its resting attitude is characteristic: its body is inclined, so that the head is the lowest part.

RAT-FLEA (PULEX CHEOPIS)

Which carries the germ of plague.

it fulfilled the expectation of those employing it, in that it caused a comparatively mild attack of the disease, yet the contagiousness of the smallpox was in no wise lessened, and those inoculated patients were often so little ill that they were not confined to bed but mingled with their fellows, with the result that although the patient himself benefited, the disease tended to spread.

I have described elsewhere the introduction of vaccination for smallpox by Edward Jenner, and here I need say only that this was the first attempt to employ a weakened virus (or "attenuated virus" as it is generally called) for the purpose of preventing an attack of a disease, and it is now recognised that an attack of a disease produced by an attenuated virus is in most cases as effective in preventing a second attack as is the disease itself; thus vaccination is as effective in the prevention of a subsequent attack of smallpox as is inoculation.

The virulence of germs can be altered in many ways; by heat, by the conditions of growth, or by passing the germ through the body of another animal. In the case of vaccination for smallpox the virulence of the germ of the disease is greatly weakened by passing it through the cow, so that, when it is introduced into the human body, it is no longer capable of causing a severe attack of the disease, but it produces instead a very mild affection which manifests itself only by a few vesicles. Yet, though the infection produced in man is so slight, it confers an "immunity" practically as potent as would have been conferred by an attack of smallpox.

The next great step was taken some eighty years later, when Pasteur was investigating the disease of

fowls which is known as "chicken cholera." He discovered the germ which caused the disease, and whilst he was studying the effect of its introduction into fowls he found that if the cultures of the germ were old, the symptoms produced when the germ was inoculated into a fowl were mild, and the bird did not die; and further, that if the same fowl was afterwards inoculated by some fresh culture, it did not die, although the same culture would kill rapidly an unprotected bird. This was a most important step, for it showed one way of weakening a germ so that it might be used to vaccinate a "susceptible animal," and thus protect it from an ordinary attack of the disease. In France chicken cholera had previously caused the death of about 10 per cent. of the fowls, yet after Pasteur's discovery less than 1 per cent. died from the disease.

The next malady studied by Pasteur was anthrax. This is a serious disease, which is liable to affect sheep and cattle. It was endemic in France, especially in the marshes of Sologne, Bresse, and Dombes. At irregular intervals it would spread from centres such as these into other districts, and the total loss of animals was very great. The disease can attack man, but this is rare.

Pasteur proceeded to search for an exact method of obtaining an attenuated virus. It had already been found that a short heating to a high temperature of a liquid containing anthrax bacilli certainly attenuated the bacilli, but it was difficult to use this method and ensure that the result was what was desired. Pasteur showed that the best method was to grow the anthrax bacilli at a temperature of 108° Fahr. At this temperature, which is much above the

"optimum" temperature for the bacilli, they grow, but no spores are formed, and the bacilli become much weakened in virulence. These attenuated bacilli he inoculated into cattle and sheep, and they became immune, and thus he was able to protect them against infection. The effect of the introduction of this method of vaccinating cattle and sheep against anthrax was very great. Millions of animals in many parts of the world have been rendered immune by this method, and the loss from this disease is less than one-tenth of what it was before the introduction of Pasteur's method. Soon after the publication of this method French insurance companies declined to insure the cattle and sheep in districts infected with anthrax unless they had been treated by Pasteur's inoculation.

The next problem which Pasteur endeavoured to solve concerned Rabies. This disease manifests itself mainly in dogs, but it may also occur in cats, deer, and several other races of animals. When it attacks man it is usually called Hydrophobia, and it results from the bite of a rabid animal. The disease is usually so rare that any vaccination against it, in the meaning of the word as applied to small-pox or anthrax, is for most people quite unnecessary, and therefore it is useless to attempt to devise any such method. As the incubation period of the disease (that is, the time after infection before symptoms appear) often amounts to months, it occurred to Pasteur that it might be possible, by means of an attenuated virus, to protect from the disease persons who had already been bitten by an animal suffering from rabies. It will be seen that the success of this method depends on the possibility of the attenuated

virus acting more rapidly than the germs which were introduced by the bite. One difficulty was, that nothing was known of the germ causing the disease, in fact it was not even known certainly that it was caused by a germ; though the communicability of rabies left little doubt on the point. It would take too long to describe in full the various methods which Pasteur employed; suffice it to say that he found that the poison was situated in the spinal cord; for if a portion of the spinal cord of an animal suffering from rabies is injected into a susceptible animal the disease will show itself rapidly and quickly prove fatal. If the spinal cord of a rabbit which has been affected with rabies is removed from the body and allowed to dry, its virulence diminishes, and the longer the spinal cord dries, the weaker is the poison it contains. In this way he was able to obtain a virus of any desired strength, and he found it possible, by commencing with a very weak virus and gradually increasing the strength, to "vaccinate" animals who had been bitten by a rabid animal so as to prevent the disease appearing.

An extension of the method to man proved equally successful, and in most countries of the civilised world Pasteur Institutes have been erected to deal with cases in which it is probable that hydrophobia would arise. It is somewhat difficult to give statistical proof of the benefit of the Pasteur method of dealing with hydrophobia, for not every person bitten by a rabid dog develops hydrophobia, but of those bitten on the bare hands or face very few indeed escape, and in cases in which hydrophobia has manifested itself recovery is almost unknown. When, however, the Pasteur method is employed

within a short time of the bite, the death-rate is under one per cent., so that we are fully justified in thinking that a very large number of lives are saved by the use of the method devised by Pasteur.

In all the instances which I have described it is evident that, by means of microbes, weakened in virulence in one way or another, we have been able to obtain an acquired immunity analogous to that form of immunity which follows, in many cases, an ordinary attack of an acute infectious disease.

The question that now calls for solution is, "What is the nature of this immunity, and how is it brought about?"

At one time it was thought that the reason why a person who had had one attack of a fever, such as measles, could not be infected a second time, was that the germs had fed upon some substance in the patient's body, and had exhausted the supply so that it could no longer exist there, as this substance necessary for its life was no longer provided. This, which has been called the "pabulum" theory, is now no longer held. The arguments against it are many. In the first place, as an attack of one infectious disease does not protect against an attack of another infectious disease, it must follow that there is a "pabulum" for each form of microbe. Secondly, persons who have recovered from any of these diseases are, in nearly all cases, as well as they were before; from this fact it would follow that these various forms of pabulum are not at all necessary for the life, or even for the well-being of the person, so it would appear that the only possible reason for the existence of these pabula would be that they might provide food for the various infective microbes.

Immunity

We have only by a long course of investigation arrived at our present knowledge of the mode in which a living body becomes "immune"; and even now, after researches in all civilised lands by hundreds of investigators, there are many obscure points and many unsolved problems. A description of the progress of the investigation should prove of interest.

More than thirty years ago, it was shown by Traube that if a small quantity of putrefying material was added to some shed blood, the blood possessed the power of remaining sweet, and from this fact it was argued that blood must possess a certain power of destroying germs. It had then to be settled whether this bactericidal power resided in the blood corpuscles or in the liquid part of the blood. Metchnikoff, of Paris, was the first to lay stress on the part played by the white corpuscles of the blood in the destruction of bacteria, and it will be worth while to understand how they do it.

In many stagnant pools and ditches and elsewhere may be found a small animal called the amœba. This holds a very low position in the scale of Nature, and is, in fact, almost one of the lowest of animals. It is microscopic in size, measuring about $\frac{1}{100}$ of an inch in diameter; it consists of a minute mass of a jelly-like substance called "protoplasm," and embedded in the middle of it is an oval body called the nucleus. This little animalcule can move from place to place, but very slowly, and it does it by putting out projections from one or other side of its body, and then the rest of the body flows after the projection. If on its way it meets with a small solid body it surrounds it and so takes it into itself. If the included particle is nutritious, it is slowly dis-

solved and disappears, and thus the amœba is supplied with food. The manner in which this is done is clearly shown in the illustration.

It is worthy of note that one form of dysentery is due to an amœba.

I have described the amœba, and its mode of taking food, because the animal can be readily obtained and examined by any one who possesses a microscope, and because its method of feeding is almost exactly similar to the way in which the white corpuscles of the blood destroy bacteria.

The blood consists of a liquid part, the "plasma," as it is called, and a very large number of minute bodies called corpuscles; most of these are coloured, and are called the red corpuscles, but some are white; and these white corpuscles are wonderfully like amœbæ. They have the same general structure; like amœbæ they can wander slowly from place to place, and like amœbæ they can engulf any small objects with which they meet; but in one point there is a great difference between them, and that is in size. An amœba may measure $\frac{1}{100}$ of an inch, but a human white corpuscle is only about $\frac{1}{2700}$ of an inch in diameter. The white corpuscles of the blood are carried along with the blood-stream, but in addition they can wander about, clinging to the walls of the arteries and veins, and even, when inflammation is present, passing through the walls of the smallest blood-vessels. In their wanderings white corpuscles may meet with bacteria, and then the corpuscle swallows one or more of the germs just as the amœba swallows its food, and the germs can be seen lying within the body of the white corpuscle. After a longer or a shorter time it may be seen that

the outlines of the bacteria become less distinct, and gradually the bacteria are dissolved. The number of bacteria swallowed by a single white corpuscle may be very great; in fact so many may be taken that they appear to occupy the whole of the corpuscle.

In this way it is certain that in the living body large numbers of bacteria which have intruded into the blood stream are swallowed and destroyed by the white corpuscles of the blood, and Metchnikoff named these corpuscles which can devour bacteria the "phagocytes" or eating-cells. It is, however, by no means certain what degree of importance is to be attached to the action of the phagocytes; Metchnikoff considered this process (which is called "phagocytosis") the most important means possessed by the body for combating invading bacteria, while other authorities look upon it as of minor importance. It is impossible, with our present knowledge, to decide between their opinions, but it is at least absolutely beyond dispute that when bacteria do enter the blood stream very many of them are swallowed, digested, and so destroyed by the phagocytes.

The outcome of the fight between the phagocyte and the microbe is not always so fortunate as I have described above. Sometimes it happens that the phagocyte has been weakened by previous ill-health, sometimes the assaulting bacteria are either more numerous or more virulent than usual, and then, instead of the swallowed germs being digested, they destroy the phagocytes that venture to swallow them, and they emerge from the combat stronger even than they were before.

It has been shown by careful experiment that it

sometimes happens that when a disease-germ attacks a person for the first time the phagocytes of his blood prove to be unskilful in dealing with it, for they are unable to swallow many of the germs; later it is found that the phagocytes have learned by experience and are then much more capable of fighting the invaders. We do not know the process by which is brought about this "education" of the phagocytes, as it has been called, but that it occurs there is little doubt.

Another very curious fact about phagocytes is that there exist in the plasma of the blood certain substances which have the property of making bacteria more readily attacked by the phagocytes. These substances are called "opsonins," because they prepare the bacteria to be eaten, for the word comes from a Greek verb meaning "to provide with food." We do not know much about opsonins; we only know that when they are present in large quantities the phagocytes feed greedily on the bacteria, but when they are scanty the phagocytes take the bacteria far less readily. These opsonins are of no little importance nowadays, both in the diagnosis of obscure infective diseases and in affording indications for their treatment.

CHAPTER IX

IMMUNITY (*continued*)

THUS we see that the white corpuscles of the blood are actively concerned in the destruction of the bacteria which invade the blood, and that they are aided by certain substances, called opsonins, in the plasma of the blood which prepare the bacteria for the attacks of the phagocytes. Natural immunity, then, is due in part at least to phagocytosis, but important though the phagocytes and the opsonins are in this matter there are other factors of even greater importance in the causation of immunity, and these exist in the liquid portion of the blood. It would be merely confusing to the reader if I were to enter even briefly into a description of our reasons for thinking that there are various substances in the blood which are antagonistic to bacteria; here it will be sufficient to say that there are such substances, and that they possess the power either of destroying the bacteria directly (and not merely indirectly like the opsonins) or of neutralising the toxins or poisons produced by the bacteria. These are all conveniently included under the term "antibodies." As mentioned above, some of these antibodies act directly on the bacteria, killing them or at least preventing their multiplication, while the action of others is limited to neutralising the poisons which the bacteria form.

These antibodies in some cases exist naturally in

the human body, but in other cases they do not appear until the body has been attacked by bacteria, and then they are developed by the body as a result of the stimulus supplied by the invading germs. To make clear this matter, so far as possible, I will describe what occurs in a simple case.

Many animals secrete poisonous substances which they can, at will, inject into their enemies, and these poisons are called their "venoms." Poisonous snakes, scorpions, some spiders, toads and salamanders may be mentioned as examples. In the venoms formed by these animals there are no germs, but they contain chemical substances, most of which are of extreme virulence. Some snake venoms are so potent that it has been calculated that a quarter of a drop is sufficient to prove fatal to a man within a short time. We may compare such a venom to the toxins produced by bacteria, and it will be instructive to consider how an antidote to snake venom can be obtained. It does not appear that the animals which habitually attack snakes, such as the mongoose and the secretary-bird, possess any natural antibodies so that they might be bitten with impunity, for they seem to depend for their safety on their agility. If a series of very small quantities of snake venom (very, very much less than would prove fatal) be injected at intervals into an animal such as a horse, it will be found, after a time, that when a poisonous dose is subsequently administered, the animal does not die, and in fact seems none the worse for the dose that would have killed it, if it had not been protected. This immunity is found to be due to certain substances, "antibodies" as we may term them, in the blood of the animal, and if some of the animal's blood be obtained, and

the liquid part or "serum" separated from the corpuscles and the clot, "antivenom" serum, as it is called, is obtained. The action of the antivenom on the venom appears to be purely chemical, the two neutralising each other, as do an acid and an alkali in a test-tube. If a suitable quantity of antivenom be mixed with a poisonous dose of snake venom and the mixture be injected into an unprotected animal, no harmful result follows. Again, if a suitable amount of antivenom serum be injected into an animal, and then, later, a poisonous dose of venom be injected, no symptoms are caused, for the antivenom already in the body of the animal has neutralised the venom subsequently injected. Nay more, if a poisonous dose of venom be injected into an animal, and then, soon after, the correct amount of antivenom be injected, in this case also the animal survives unharmed. But it is absolutely essential that the interval between the injection of the poison and its antidote should not be too long. If the dose of poison is such as would naturally kill the animal in three hours, the antidote must be given not later than one hour after the poison. Still further it has been found that if an animal be bitten by a venomous snake, an injection of the antivenom serum, administered soon after the bite and in a suitable amount, will avert death. This is not only true of animals. Since 1895, when Calmette first prepared an antivenom serum, many cases have been recorded in which the lives of human beings have been saved by the timely injection of the serum. Only too often the serum is not at hand when it is wanted, and the virulence of the poison generally precludes the possibility of obtaining the antidote in time to be of use. In countries where venomous

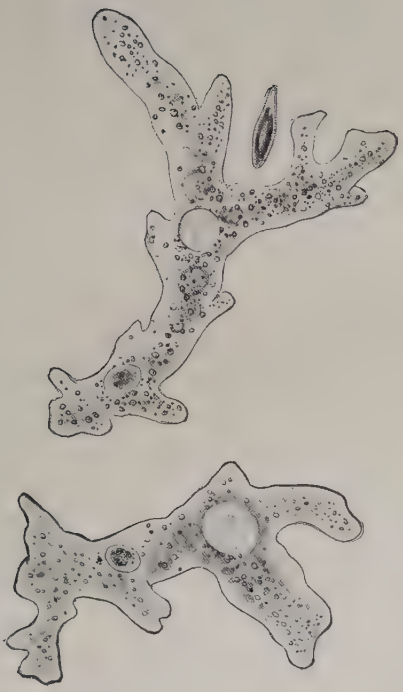
snakes are common, it is likely that the serum may be more available than where snakes are rare. In India there are some 30,000 deaths from snake bites every year; but it is hardly possible to expect that in any large proportion of the cases of snake bite it will be possible to have recourse to curative serum. Nevertheless, its production is distinctly a step in advance in medicine.

I have selected snake venom and the mode of obtaining its antidote as a simple example of the formation of antibodies in the animal body as the result of the injection of small doses of a toxin. I will take next an instance in which antibodies have been produced for the cure of a disease caused by bacteria. Diphtheria has doubtless existed for many centuries and, in fact, we have a description by Aretaeus of it dating as far back as the second century A.D., and epidemics of it appear to have occurred from time to time in several countries in Europe; but in these earlier accounts it is probable that other throat affections were confused with the disease, and it was not till 1821 that it was clearly separated from other affections resembling it. The most decisive step was not taken till 1883, when the bacillus causing the disease was first clearly described by Klebs and Löffler. Diphtheria is a disease which mainly attacks the throat and windpipe, and it chiefly affects children, though adults are also liable to it. It is found in most civilised countries, but it is not common in the tropics. It is prevalent in this country, but in some foreign countries it occurs much more frequently.

It is extremely contagious and occurs in epidemics, though single cases are not rare. It forms a "mem-

brane" over the affected surface, and in fatal cases death is generally due to obstruction of the breathing, though it often happens that the fatal result is brought about by the poisoning effect of the disease on vital organs. Even when recovery follows an attack, it is by no means rare to find that serious sequelæ have been left behind, and of these the most important is paralysis. The mortality from diphtheria has always been high, and formerly it varied probably between 30 and 50 per cent. It is quite certain that diphtheria is due to the "bacillus diphtheriæ," and the bacillus causes the disease by a poison or "toxin" which it secretes.

The problem of treatment was, then, not very dissimilar from that of poisoning by snake venom; and it was solved in 1894 by Behring and Roux, who prepared an "antitoxin serum" for the treatment of the disease. The mode of preparation is as follows: A culture of the diphtheria bacillus is made by putting bacilli, taken from a case of the disease, into some broth which is kept at a suitable temperature; the bacillus grows freely and forms a toxin which mixes with the broth. The broth is then filtered, so as to obtain it free from diphtheria bacilli. This broth, which contains the diphtheria toxin, is then injected into a horse at intervals in gradually increasing doses. This leads to the formation of large quantities of antitoxin in the horse's blood. After a time some blood is drawn off, the clot and the corpuscles are separated, and the serum that remains is the "antitoxin serum," which is used in the treatment of diphtheria. When its strength has been tested it is ready for injection. The earlier in the disease the serum is injected the more striking are its effects; but even in



AN AMŒBA

This is a low form of animal, and in shape and movements it resembles a white corpuscle of the blood. In the upper figure an amœba is about to surround and swallow a minute form of plant.

A "CULTURE" OF DIPHTHERIA BACILLI

A culture-tube containing serum, on which are seen small white patches. These are masses of the bacilli of Diphtheria, which have been grown in an incubator.

a somewhat late stage it may do good. The result of the use of the serum in diphtheria has been remarkable; the mortality, which was rarely below 30 per cent., has steadily declined; year by year it has diminished as the use of the serum has become more widespread and as the cases of the disease have been treated at an earlier stage. Further, we have learned more as to the best dose to be given, and the quantity now administered is larger than at first. The death-rate at present is under 10 per cent., and it has been estimated that in London alone the lives of more than a thousand children are saved every year by the use of diphtheria antitoxin serum. Here, then, is a veritable triumph of modern medicine, based, not on properties accidentally discovered, but on observations carefully made and experiments accurately carried out. Diphtheria antitoxin is also sometimes used prophylactically, that is to say, to protect the healthy from an attack of the disease. When diphtheria has broken out in a household containing several children, it is well to treat with the antitoxin not merely those who manifest signs of the disease, but also the others who have been exposed to the risk of infection. By adopting this practice it has been found possible to stay an outbreak at the beginning. The protection afforded by a prophylactic injection of diphtheria antitoxin is not permanent; its exact limits are not known, probably it does not last longer than a few weeks; but even this period is sufficient to prevent the appearance of the disease after exposure to infection.

This method of using the serum of artificially immune animals for the curative treatment of an infective disease is, at present at least, not very widely applicable; in fact the only other disease in addition

to diphtheria in which it is commonly employed is tetanus, or "lockjaw," as it is popularly called. This is caused by a bacillus with a swelling at one end, due to the presence of a spore, so that it has been named the "drumstick bacillus." This germ lives chiefly in mud, and therefore wounds into which mud has been forced are specially liable to become infected with it. The antitoxin serum of tetanus has the most beneficial effect when it is administered very early in the disease, and there can be no doubt that it may have a preventive action; therefore many surgeons consider it advisable to inject some of the tetanus antitoxin in all cases where the likelihood of infection with this microbe is great. It is impossible from the very success of its action to prove absolutely that the antitoxin really does prevent the appearance of the disease, for it may always be said that in these cases no infection has occurred; but it is recognised that where such prophylactic treatment is adopted, tetanus is never, or hardly ever seen.

These methods of producing an artificial immunity by the injection of a serum containing antibodies produced in other animals has been aptly called "passive immunity," because the body of the person injected has taken no part in causing the immunity.

We come now to a more complex method of treatment of disease by means of antibodies. In the case of diphtheria, the broth in which a culture of the diphtheria germ was made contained the toxin of the disease, that is, the toxin is excreted by the bacillus; but this is not the case with the germs of all infectious diseases. In many, the toxins formed remain within the bodies of the bacteria, and therefore the injection of the filtered broth in which the germs

have grown will not give rise to any antitoxins. In cases such as these it is necessary to inject the bacilli themselves, though it is, of course, necessary to kill them before injecting them. The injection of this emulsion of dead bacilli leads to the formation in the body of antibodies of various kinds. The opsonins also are increased in amount, and altogether the defensive powers of the body are strengthened. These emulsions of dead bacteria have, somewhat unfortunately, been called "vaccines," for they are liable to be confused with the true vaccines which contain the germ of the disease, living but attenuated in strength and able to multiply in the body.

The vaccines containing dead bacteria are injected into the patient, and the antibodies are elaborated by the patient's own body, and not, as in the case of antitoxic sera, in the body of another animal. The number of bacteria contained in a suitable dose of a "vaccine" may be very large, for it may amount to tens of millions or even to hundreds of millions. These vaccines have been employed in a very large number of diseases, and of their value no one who has had much experience of them can doubt; but their introduction is at present comparatively recent, and therefore we are hardly in a position to speak with certainty about the value of all of them.

As to several of these vaccines there cannot be any real doubt. For instance, it is not rare for some persons to be exceedingly liable to attacks of boils, and many of these boils are caused by micrococci. It has been found repeatedly that the injection of one or more suitable doses of a vaccine containing this micrococcus will be followed by the rapid disappearance of the boils. The preparation of a vaccine

is fairly simple. A suitable culture medium is taken and is inoculated with the required microbe; this is incubated at the correct temperature, until the microbe has increased enormously in numbers. Then the germs are killed, and the "vaccine" is ready for injection. In some cases a vaccine prepared from an ordinary culture of the germ may be employed, but in other cases it seems to be essential to employ for the culture some of the germs obtained from the patient himself.

The acquired immunity resulting from the injection of a vaccine is called "active immunity," because the patient's body itself manufactures the antibodies; while, as I have mentioned already, the immunity produced by an antitoxin serum is called a "passive" immunity, because the antibodies have been prepared in the body of another animal.

In all these methods we have powerful aids in the treatment of disease, and we may be sure that in the future their value will be far greater than it is at present.

CHAPTER X

VACCINATION

I HAVE thought it well to deal with the subject of vaccination in this work, for it was certainly the earliest attempt to prevent disease by means of protective methods closely allied to those which Nature provides. Vaccination is, moreover, typical of one mode of dealing with bacterial infection which is being employed widely at the present time.

Before we can appreciate fully the advantages which have been gained through vaccination, it is necessary that we should have a clear idea of the conditions which existed in this country when small-pox was uncontrolled. The disease was first recognised and described as a separate affection in the fifteenth century, though in all probability it had existed at least for many centuries before that. When we first come upon a clear description of small-pox, we find that it was a disease almost confined to childhood—in fact, very much in the position of measles in the present day; and this was due mainly to the fact that nearly all adults had had the disease, and the adult population practically represented for the most part the survivors from small-pox in childhood. There were, indeed, some who appeared to be insusceptible to the disease, and these were thought to amount to about 5 per cent. of the population. Small-pox then attacked almost all of those who were

exposed to its influence, unless they had already had an attack of the disease; for, fortunately, the disease in large measure protects against itself.

The frequency of small-pox in England in former centuries is not to be measured by the severity of any single epidemic, because in every epidemic the persons who could be attacked formed only a comparatively small part of the population. For epidemics came so often that at any one time the vast majority of the people had already had small-pox, and therefore it was only amongst those who had never had small-pox that it was possible for the disease to spread. Even with these great limitations of the activity of the disease in any one year, small-pox killed thousands in London alone when it became epidemic every few years. In isolated parts of the country, however, the case was somewhat different, for there children frequently escaped the disease, so that when later small-pox infection was brought into the district, the disease was no longer limited to the children, but attacked persons of all ages. The full virulence of the affection could be only seen in epidemics in countries where either it had never appeared before, or where for many years the disease had not been seen, for when it did come the population was entirely, or almost entirely, defenceless, and the results were indeed terrible.

In Iceland, in 1707, small-pox had been absent for nearly forty years, yet when it did appear it slew eighteen thousand persons out of a total population of fifty thousand in the three years 1707, 1708, and 1709. Greenland had its first epidemic of the disease in 1734, and two-thirds of the inhabitants perished. When small-pox first appeared in Mexico it is said

to have swept over the land like fire over a prairie, and so great was the number of those who died of the disease that there was no possibility of burying them. Amongst the North-American Indians whole tribes are said to have disappeared. In England the disease appeared epidemically so frequently that though in each epidemic the numbers dying formed only a small part of the total population, yet the total mortality for a term of years from small-pox was very great.

The ordinary mortality of the disease appears to have been about one in seven of those attacked, but in some of the epidemics the mortality was much higher, even reaching one in three. During the latter half of the seventeenth century in London the average number of deaths from small-pox was over one thousand a year, and as the population then was probably a little over half a million, and as it has been estimated that there was, on an average, one death in five cases of the disease, we shall probably not overestimate the number of cases if we say that there were five thousand cases of small-pox every year in London at that time.

Dr. Jurin in 1723 calculated that more than seven per cent. of all deaths were from small-pox; and this statement was based on the London Bills of Mortality. From various data referring to other parts of the country it appears that, speaking generally, the death-rate from small-pox was during the eighteenth century about three thousand per annum per million living.

It was considered rather a misfortune not to have had small-pox while young, and "few people would choose even to hire a servant who had not had the small-pox."

Vaccination

The first attempt made to mitigate the ravages of the disease was by the practice of inoculation. For centuries, in the East, it was known that a mild attack of the disease could be produced by taking some of the matter from a case of small-pox and inserting it in a minute incision of the skin. It is difficult to say where inoculation first started, but there seems to be some evidence in favour of the view that it originated in Circassia. The first mention of the matter is contained in a letter from Constantinople, written by Emanuel Timoni, and communicated to the Royal Society by Dr. Woodward in 1714. It was also described in a book published by Kennedy in 1715, and he gives a full account of the methods employed. The practice prevailed amongst the Arabs, and we are told, at Mousul the appearance of small-pox was announced by a public crier, so that those who wished might have their children inoculated. Inoculation was a very ancient custom in India, and in China it had been practised about two hundred years.

In 1720 Lady Mary Wortley Montagu, whose husband was Ambassador at Constantinople, learned of the method there, and introduced it into England, and she showed her belief in the value of the method by having her little boy inoculated in England in that year.

Slowly the practice was adopted, but after a time it became more widely used, and, as I have mentioned in the chapter on Immunity, it often caused so little disturbance to the persons inoculated that they were not confined to bed, and therefore, as they mixed with their friends, they tended rather to spread the disease. The opinion has been expressed by some

that inoculation increased the mortality from small-pox, but it is certain that a very definite increase in the death-rate from small-pox had occurred in this country before inoculation was introduced.

The value of inoculation was definite for the individual, but on the whole it was harmful to the community; yet it continued until it was replaced by vaccination.

For a long time, it is difficult to say how long, in several parts of the country, especially in the West of England, the belief had existed amongst those who had to do with cows, that a disease from which cows sometimes suffered, called cow-pox, when communicated to the milkers afforded them protection from small-pox. It is certain, at all events, that attempts made to inoculate dairymaids often failed when they had suffered previously from an attack of cow-pox. Mr. Rolph, who practised at Thornbury in Gloucestershire, estimated that he had met with sixty cases in which he had failed to produce small-pox by inoculation, and all of these cases were persons who had been previously affected with cow-pox. The tradition was well known to inoculators, though some did not believe it.

In 1771 it is said that a butcher living near Bridport was intentionally inoculated with the cow-pox, because it had been suggested to him that it would be the means of preserving him from the small-pox. After he had recovered from the cow-pox he was twice inoculated with small-pox, but each time unsuccessfully. There is good evidence also that a farmer named Benjamin Jesty of Yetminster, in Dorset, had inoculated his wife and two children with cow-pox in 1774, in order to prevent their taking small-pox,

but the particulars were not published until after Jenner's discovery.

Edward Jenner was born in 1749 at Berkeley, in Gloucestershire, and when eight years old he was inoculated for small-pox. The preparation for the inoculation lasted six weeks, and during this time he was bled, kept on a low diet, and given a "diet drink to sweeten the blood." At the age of thirteen he was apprenticed to a surgeon at Sodbury, near Bristol, and there he remained for six years. While an apprentice an incident occurred which it is said first turned his attention to cow-pox. A young country-woman who was being treated, told him that she could not take small-pox as she had had cow-pox. At the age of twenty-one he went to London, and there he became a pupil of the celebrated surgeon John Hunter, with whom he lived for two years. He assisted Hunter in forming the valuable museum, which later became the foundation of the Museum of the Royal College of Surgeons of England.

After studying in London he returned to Berkeley, where he commenced practice. Here, in addition to his professional work, he interested himself in many Natural History subjects, and he appears to have been the first to recognise that the young cuckoo itself turns out the other young birds from the nest in which it lives. The fact has been denied many times since, but a few years ago it was shown to be true. For some years Jenner interested himself in the natural history of cow-pox, and he believed that it spread to cows from a disease of the heel of the horse called the "grease." From observation he proceeded to experiment, and in 1796 he had vaccinated several cases with lymph taken from cases of cow-pox, and

in each case a subsequent attempt to inoculate with small-pox failed. Jenner wrote a paper on the subject and sent it to the Royal Society, but it was not approved by the Council of that body, and therefore it was returned to him.

His pamphlet was published in 1798, and it was called "An enquiry into the causes and effects of the variolæ vaccinæ, a disease discovered in some of the western counties of England, particularly Gloucestershire, and known by the name of the cow-pox"; and in it he explains his reasons for thinking that cow-pox can prevent small-pox.

At first the new idea was not very readily received, but gradually the practice of vaccination spread. There were several who opposed it, and some cases occurred which seemed to throw doubt on its efficacy, but the successful cases were so numerous that the apparent failures were disregarded. The practice spread to the continent of Europe and to America, and it was received almost everywhere with enthusiasm, an enthusiasm which appears strange to us who see so little of small-pox. Practically within six years vaccination became known and employed throughout the world. Jenner spent the rest of his life in advocating his discovery, and in taking care that real vaccine lymph was employed.

Jenner himself believed that he had discovered "an antidote capable of extirpating from the earth a disease which is every hour devouring its victims—a disease that has ever been considered the severest scourge of the human race." It was not long, however, before this view had to be modified. It had almost been forgotten that small-pox itself does not always prevent a subsequent attack of the disease, and even when

inoculation was common, occasionally an attack of small-pox occurred in persons who had been previously inoculated.

Further, it was at one time thought that a single vaccination would confer complete immunity for the rest of life, but it has been found that after a time a tendency exists for the patient to lose this immunity, for it seems clear that the immunity does diminish after some years, and therefore there is need for re-vaccination. With vaccination and re-vaccination efficiently performed, practically complete immunity is afforded.

In spite of vaccination small-pox still lingers in this country. To what is this to be attributed? At the present time vaccination is theoretically compulsory, though in some towns, such as Leicester, those in authority neglect to carry out the provisions of the act authorising compulsory vaccination. Further, it is now legally possible for parents who declare that they have conscientious scruples against having their children vaccinated, to obtain permission for the non-performance of the vaccination.

There is, then, slowly growing up amongst us a large body of unvaccinated persons, and these form a body of material on which the disease flourishes when it appears. Further, it must not be forgotten that the mode of performance of vaccination is not always satisfactory. There appears to be some connection between the number of vaccine pustules formed and the amount of protection afforded. When in the early sixties a great many vaccinated children were examined, it was found that only one in three could be considered well protected. It is not improbable that before many years an epidemic of small-pox will

appear in this country which will demonstrate the unsatisfactory condition of the enforcement of the law of compulsory vaccination.

The best example of a well-vaccinated country is Germany. In the entire German Empire the average mortality from small-pox in the ten years ending 1899 was 1.07 per million, that is to say, about one-tenth of the English rate in the same years. Vaccination in Germany is compulsory, and re-vaccination is compulsory when all children are at school age, and when recruits are enrolled they are again vaccinated.

At the present time it is customary nearly everywhere to employ calf vaccine, that is to say, lymph obtained from calves which have been vaccinated. Before the calves are vaccinated, they are tested for tuberculosis. This lymph, taken from the calves, is diluted with glycerine; this serves not only to increase the number of cases which can be vaccinated with a certain quantity of vaccine, but also to kill many of the extraneous germs which may happen to be present.

An important question has to be answered. Does harm ever follow vaccination? It may confidently be said that if due care be taken in the source of the lymph, and if the operation is performed with due care on healthy children, no harm will ever follow. If, however, care be not taken, severe or even serious results may follow.

Vaccination used to be performed from arm to arm, and, provided that the giver of the lymph is perfectly healthy, the practice is perfectly safe; but it is often not possible to be certain that the child from whose arm the lymph is taken is in perfect health; and in many of the cases where harm has followed vaccina-

tion, it has been due to the fact that the source of the lymph has been tainted. It is obvious, further, that the child about to be vaccinated must be in good health, that its arm must be clean, and that the instrument with which the operation is performed must be aseptic. Even, however, when all these precautions have been taken, harm may follow because of the neglect of those whose duty it is to look after the child. The vaccinated area should always be protected by a piece of clean linen. "Vaccination shields" are often employed, and they are saved from one case for use on subsequent cases, with the result that they are generally very septic and fully capable of spreading disease. It may be seen, therefore, that with due care the risk of danger resulting from the operation of vaccination is extremely small, but were the risk greater even than it is, it would be well worth while taking in order to obtain immunity from small-pox.

I have said little hitherto as to the theory of vaccination. Nearly all observers now agree that cow-pox is really small-pox of the cow, so modified by its passage through that animal as to have lost nearly the whole of its virulence; but it appears that it is still capable of giving rise to the formation in the body of the person vaccinated of those antibodies which are formed naturally in a case of small-pox and which are capable of antagonising both the organism of small-pox and the toxins to which that organism gives rise. In the chapter on Immunity, other instances are quoted of weakening of the virus of a disease. The conditions of growth determine the virulence of a microbe, and the growth of the microbe of small-pox in the cow so weakens it as to make it, when re-inoculated into man, a mild disease.

CHAPTER XI

DIAGNOSIS

Diagnosis is the technical name for the recognition of a disease. Sometimes it is very easy, the disease being recognisable at a glance; while at others it is extremely difficult, and all the assistance provided by the numerous aids to diagnosis which we possess may be required before a certain opinion can be formed.

No small part of the greater success which attends modern treatment when compared with the treatment of former days is to be ascribed to the vast improvements made in the art of recognising a disease and of distinguishing one disease from another.

A correct diagnosis is the first step in treatment; nay, more, it is hardly an exaggeration to say that an exact diagnosis, a correct appreciation of the whole morbid condition present in the patient, is half the treatment. It is true, that even with an incorrect diagnosis a cure may be possible, but this is due, partly to the fact that the same treatment may be efficacious in several different diseases, and partly to the power which the body possesses in a high degree of curing itself; the *vis medicatrix naturæ*, or the healing power of nature, is capable of doing much.

There are not rarely occasions when the physician or the surgeon has to acknowledge that he is unable to say exactly from what malady the patient is suffering; this is not uncommon at an early stage of a dis-

ease, but usually, before long, new symptoms or signs appear on which the diagnosis can be based. A refusal to make a diagnosis, when the facts needed for it are unobtainable, is not to be taken as any proof of ignorance; it may well be an evidence of knowledge, for a man less acquainted with the subject might have less hesitation in framing an opinion.

We see, therefore, that though a good result may follow an incorrect opinion as to the nature of the disease, every effort should be made to find out exactly what affection is present. Even in a machine so simple as a watch, the recognition of what is wrong must precede any really intelligent attempt at putting it right. It is unnecessary to say more in support of the immense importance of a correct diagnosis.

A diagnosis is based partly on the history of the patient, partly on his own account of his symptoms, and partly on the physician or surgeon's examination of the patient. The relative value of these three sources of information varies in different cases. Sometimes, as in the cases of infants, no account can be obtained of what the patient feels. On the whole the most important of these sources is the information obtained from the examination of the patient, and in this matter the progress of science has given to the medical profession several diagnostic aids of great value, and in this chapter I will describe some of the more important of them.

Percussion

One of the first great steps in the extension of our diagnostic powers was the introduction of per-

cussion. Before this time the physician's knowledge of the interior of the chest was based chiefly on the presence of various symptoms, such as cough, shortness of breath, feverishness and wasting, but of direct knowledge there was almost none. In 1761 Auenbrugger of Vienna introduced into medicine the method of percussion.

The value of percussion depends on the fact that a membrane when struck will vibrate freely and give out a sound if it is surrounded on both sides by air or other gas; but it will not vibrate if on even one side a liquid or a solid substance is pressing against it. Thus a drum will give out a clear sound when struck, only if there is air on both sides of the drumhead; if either side is in contact with a solid, only a dull sound will be heard, and the same result will follow if either side is in contact with a liquid. The explanation of these facts is that air must surround a membrane if it is to vibrate freely, and the larger the surface that can vibrate the deeper the note. When a solid or liquid touches one surface of the membrane, its freedom of movement is so greatly obstructed that it cannot vibrate freely, and as a result a dull note is produced.

Although the use of percussion in diagnosing the condition of the chest was introduced by Auenbrugger in 1761, it was not until 1808 that, in consequence of Corvisart's advocacy, the method became widely used. Its great value is clear. The heart consists of so much solid material, and it lies so close to the surface of the chest, that the percussion sound over it is quite dull, but where the lung is close beneath the chest wall the sound obtained by percussion is clear and resonant, because the lung contains a very large

proportion of air. Therefore the percussion note over a healthy heart is dull, and over a healthy lung it is clear. When, however, as a result of inflammation, as in pneumonia, portions of the lung become much more solid than in health, the note obtained by percussion will be duller than normal.

In this way, by means of percussion, it is possible to learn much as to the conditions existing within the chest, and percussion is almost equally useful in diagnosing the affections of the abdomen. The way in which percussion is performed has varied somewhat from time to time. At first the chest was tapped with the finger, but the sound so elicited was not definite. Later a small block of ivory or ebony or some similar substance, called a "pleximeter," was placed on the part to be examined, and this was struck with a small hammer or with the finger. At present it is customary to place a finger of the left hand over the spot and to strike it with a finger of the right hand. With practice as clear a note can be obtained in this manner as is possible with the use of an instrument, and it is much more convenient for the physician not to have to carry about with him a special instrument.

Another and perhaps even more valuable method of examining the organs of the chest is auscultation.

Auscultation

About the beginning of the nineteenth century it had become not unusual for many physicians of Paris to listen to the sounds of the heart by placing the ear to the chest, and in 1819 Laennec, who had employed this method of listening to the heart,

thought that the heart-sounds could be conveyed better to the ear if some solid medium were interposed. He experimented with a roll of paper, and he found that he could hear the sounds more distinctly, and therefore he devised the "stethoscope." This instrument consists essentially of a cylinder with a central perforation, and at each end is an enlargement—at one end for the physician to apply to his ear, and at the other for application to the chest of the patient.

By employing the stethoscope Laennec was able to hear, not only the sounds of the heart, but also the sounds which are given out by the lungs in health and disease, and he may be said to have founded the art of diagnosis by auscultation.

Some additions have been made to the conclusions at which Laennec arrived in the auscultation of the heart and lungs, but these additions have been small, and to his investigations was due a very great advance in the diagnosis of the organs contained in the chest, so that at the present time the physician, by means of percussion, auscultation, and other similar methods, is able to arrive at very accurate conclusions as to the conditions existing within the chest. The stethoscope of Laennec was about a foot in length, and its portability was somewhat increased by making it in two pieces which were screwed together for use. A little later Pierry made a smaller and lighter instrument, removing most of the wood between the two ends, which were left larger; the end for the patient's chest being smaller than the end intended for the physician's ear. This pattern has endured to the present day, and it is preferred by many, but a more convenient pattern has, in a great measure, replaced it. This is

called the binaural stethoscope, for it is made to apply to both ears of the physician. The "chest-piece" for applying to the patient's chest is very much the same as the chest-piece of the wooden stethoscope, and from it come two tubes which are connected by means of rubber tubing to the earpieces. The advantages of this form of stethoscope are, that both ears are utilised in hearing and that it is more easily applied to all parts of the chest of the patient. Although Laennec, the inventor of the stethoscope, considered that it assisted the hearing, this opinion is not held by most physicians, for it is now generally agreed that by placing the ear to the chest the physician can hear more clearly than by means of a stethoscope; but the "direct method" of auscultation, as it is called, has many inconveniences, and the stethoscope is much more readily applicable.

By means of auscultation disease of the heart can be recognised. The condition of the lung also and of the pleura which surrounds it can be ascertained with a high degree of accuracy.

The Clinical Thermometer

One of the most striking deviations from health occurring in many diseases is an elevation of temperature. From the earliest times the presence of fever was well known to those who had the care of the sick, but it was not possible to recognise with certainty slight elevations of temperature merely by feeling with the hand, or to detect small variations occurring during the course of a febrile attack. The thermometer was used long ago occasionally in medicine, but it was not till 1860 that its use became

at all common. At first the clinical thermometer was large, but now it is very small and portable.

The thermometer is placed under the arm or in the mouth under the tongue. In the mouth the temperature is generally about half a degree higher than in the armpit. The normal temperature of the mouth is about 98.6° Fahrenheit, corresponding to 37° Centigrade, and this point is usually marked on the thermometer by an arrow.

At first it was necessary to wait some five minutes before the mercury in the thermometer had risen to its full height, but now, by making the glass thinner and the bore narrower, it has been possible to obtain thermometers which will give a true reading in a minute or even half a minute, though it is always well to leave the instrument in position for a little longer time than it is said to require. In the early thermometers it was necessary to observe the level to which the mercury had risen before removing the thermometer from its position in the mouth or under the arm, for the mercury would begin to fall even while the thermometer was being removed from its position. It was not very long, however, before an ingenious device was invented which served to retain the mercury at the height to which it had risen. The bore of the tube was greatly constricted at a point a short distance above the bulb. The great force exerted by the expanding mercury is sufficient to force some of the mercury past the constriction into the tube above, but this portion of the mercury cannot return past the constriction as its weight is insufficient, and therefore the upper border remains at the level it had reached while in the mouth or armpit.

In many modern clinical thermometers the front

of the instrument is curved, so that it acts as a lens and enables the fine column of mercury to be more easily seen. Still another improvement has been introduced. In most clinical thermometers the degrees are scratched on the outside of the glass. This arrangement has several disadvantages, of which the most important is that in the scratches might lodge bacteria, and these might not be removed when the thermometer is cleansed. In some recent instruments the degrees are marked on the interior of the glass, so that the surface is perfectly smooth, and it is therefore much more easily kept clean.

Although 98.6° is called the normal temperature, it must not be forgotten that even in perfect health the temperature may vary nearly a degree, the highest temperature being found at night and the lowest in the early morning. The judicious use of the thermometer is of great value in the recognition of disease, and if the temperature is found in any case to be normal, it is possible to exclude many morbid conditions. It is, however, possible to pay too much attention to the thermometer, and unfortunately many people are in the habit of taking frequently their own temperatures and the temperatures of their children, and if even a slight rise is present they are worried; for they imagine that some disease is commencing. This is foolish, for it is a misuse of a useful instrument, and it causes much unnecessary anxiety.

The Ophthalmoscope

The treatment of all but the superficial diseases of the eye was unsatisfactory so long as surgeons were unable to see into the interior of the eye during life.

On attempting to look into an eye through the transparent pupil it appears quite dark, and nothing can be seen because the head of the observer completely shuts off all light from the observed eye. Sometimes if an eye is looked at from a distance of five feet or so, it is possible to see through the pupil a red glare which is really the structure at the back of the eye. This is often seen in animals: in dogs the colour is usually green. It is only possible to observe the retina in this way when sufficient light can get into the eye, and the further the observer's head is away from the observed eye, the less it blocks out the light.

The ophthalmoscope was invented by Helmholtz in 1851. In its earliest form it consisted merely of a plate of glass placed obliquely between the observer and the observed eye. Rays of light from a lamp fall on to the glass, and by it are reflected into the observed eye; the rays emerging from the eye pass (in part at least) through the glass and enter the observer's eye, who, in this way, can see the interior of the patient's eye. In a later and much more effective form, a mirror with a central perforation replaces the glass plate, and a much better view is obtained.

There are two methods of using the ophthalmoscope; in one, which is called the "direct method," the observer's eye is placed near to the observed, and the rays of light pass straight from one to the other. In the other method, which is called the "indirect," the observer is about two feet from the observed eye, and a convex lens is interposed between the mirror and the observed eye. In this way a real image is formed which is seen by the observer. In all modern ophthalmoscopes, lenses both concave and convex and of various strengths are placed behind the mirror,

and these are used to correct any error of refraction on the part of either the physician or the patient. The ophthalmoscope, in addition to its very great value in diagnosis, is also used to estimate the power of the spectacles required in cases of defective vision due to errors of refraction ; and the results obtained by the ophthalmoscope can be employed to confirm or correct the results obtained by the patient's attempts to read type ; and further, the ophthalmoscope can be employed to ascertain the errors of refraction in young children who are unable to read.

The Laryngoscope

The larynx is the upper part of the air passage, and contains the apparatus for producing the voice. The difficulty of ascertaining what changes occurred in the larynx during life had rendered it very difficult to know the conditions existing in it, and therefore treatment was often unsatisfactory.

The laryngoscope is an instrument devised for examining the interior of the larynx. It was invented by Babington in 1829, and he described it under the name of "glottiscope." Similar attempts were made by Liston and Trousseau. Little was really done, however, till 1854, when Garcia the celebrated singer improved the method. He reflected the rays of the sun into the back of his mouth by means of a mirror which he held in his left hand; then he introduced a dental mirror into his mouth, and thus he was able to see an image of his own larynx in the mirror. He was able to study the movements of the vocal cords, both when at rest and when sounding a note.

Diagnosis

The laryngoscope consists essentially of two mirrors. One of these measures four inches or so in diameter, and is fixed to the surgeon's forehead. This mirror is concave, and has in its centre a perforation through which the surgeon can look. The other mirror is much smaller, about an inch or less in diameter, and it is fastened at an angle to a long handle. The laryngoscope is used in the following manner. The patient sits on a chair, and on one side of his head is a good light. The surgeon with the large mirror on his forehead is seated opposite the patient, and arranges the mirror so that the light is reflected by the forehead mirror into the patient's mouth. The patient puts out his tongue and holds it steady with a cloth, or sometimes the surgeon holds the tongue. The surgeon then takes the small mirror and warms it, so that the moisture from the patient's breath may not condense on it and so obscure the view. The small mirror is then passed with care into the back of the throat. The rays of light are reflected by the forehead mirror into the patient's mouth, where they meet the small mirror and are reflected into the larynx, which they illuminate. The returning rays are reflected by the throat mirror, and so find their way back to the surgeon, passing through the perforation in the large mirror. The discomfort produced by the mirror in the throat may be prevented by swabbing the part with a solution of a local anæsthetic, such as cocaine.

In this manner with practice a very accurate view can be obtained of the interior of the larynx, and with the assistance of the laryngoscope applications can be made to the vocal cords or other structures, and small growths can be removed.

Diagnosis

Within the last few years a new method has been invented of examining the larynx. It is called "direct laryngoscopy"; for it is possible when the head is thrown far back to pass a straight instrument through the mouth directly into the larynx, or even farther still. In this way not only can the larynx be examined with great ease, but it is also possible to see the lower part of the air tube (the trachea, as it is called), and even the upper part of the bronchi.

Through the cavity of the direct laryngoscope instruments can be introduced into all the main air passages, and foreign bodies, such as pins, can be removed with a certainty and ease impossible before. The risk to the patient has been greatly reduced, and a process occupying a few minutes has, in suitable cases, been substituted for a long and difficult operation.

Röntgen Rays

One of the greatest helps to the surgeon in the diagnosis of injuries and disease of bones and joints has been afforded by the discovery of the Röntgen, or X-rays.

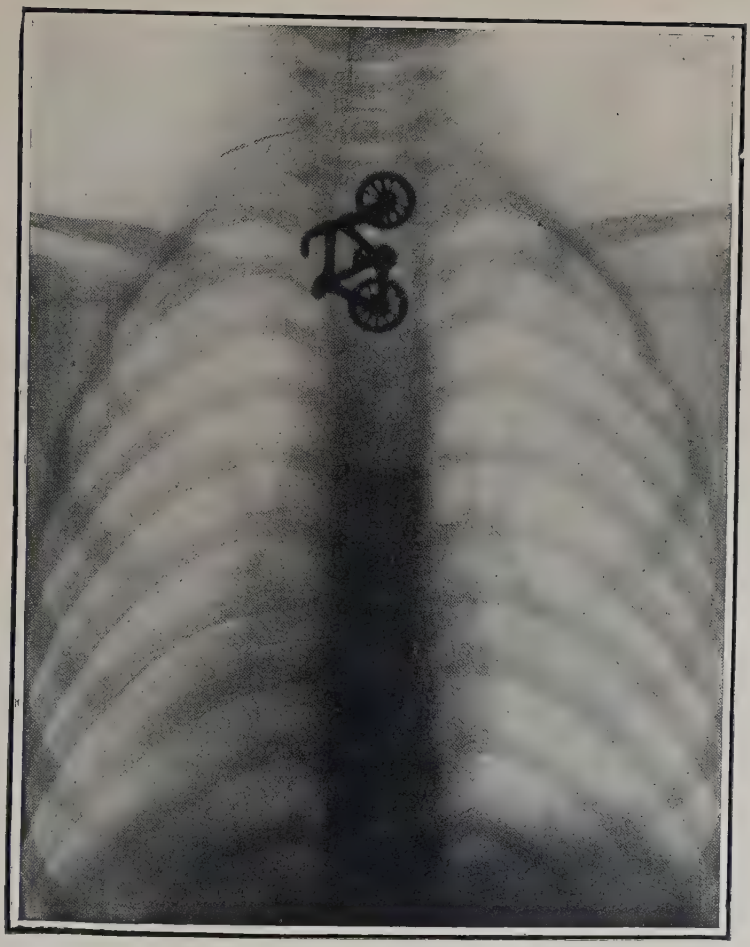
There are several methods by which Röntgen Rays can be obtained, but the simplest is perhaps the following:—A primary electric current is taken from an electric battery, from accumulators or from the electric light mains, and the last of these is certainly the most convenient for ordinary purposes. This primary current is sent through the primary coil of an "induction coil," and it is "broken" many times a second by a special kind of interrupter. The effect

of this rapid interruption of the primary current is to induce in the "secondary" wire of the coil a current of very high voltage. Wires from the secondary poles are led to an X-ray tube. This tube consists of a glass globe, and at one end is a small metal disc called the negative pole or "cathode," and at the other end is the positive pole, or, as it is often called, the "anticathode." In some tubes there are two anticathodes, but it is not certain that this is any improvement. The anticathode is made of platinum, and it is inclined at an angle of 45° to the axis of the tube. Nearly the whole of the air in the tube is pumped out before the tube is sealed, and then it is ready for use. When an electric current of very high voltage is passed through such a tube from which nearly all the air has been pumped, particles of air containing charges of negative electricity pass from the cathode towards the anticathode, which they strike, and reflected from this they are turned sideways towards the glass, which glows with a green tint, and from the glass the Röntgen Rays pass off. These Rays are invisible to the unaided sight, and they possess the power of passing through many bodies which are opaque to ordinary light; thus paper and wood offer very little resistance, while metals offer great resistance to the Röntgen Rays, and the heavier the metal the greater the resistance. If an X-ray tube is placed on one side of a limb and a photographic plate is placed on the opposite side, and a suitable current is passed through the tube, it will be found, on development of the photographic plate, that the plate will have been affected unequally by the rays, according to the structures intervening between the lamp and the plate. The

skin and the muscles will have allowed nearly all the Rays to pass through them, but the bones will have obstructed the greater part of the Rays, so that beneath the bones the photographic plate will have been but little affected.

Before this important addition to our diagnostic aids, the surgeon was generally able to recognise with accuracy most of the fractures and dislocations he met with; but Röntgen Rays have greatly increased his diagnostic power. Even at present the surgeon still diagnoses the condition present by inspection and palpation; but he has in the X-rays a means of testing, confirming, or correcting the opinions he has previously formed. In most cases his diagnosis is found to be right, but sometimes it happens that the Rays show, on the print or "skiagram" as it is called, that some other bone or joint injury is present in addition to what was at first thought. Thus as the surgeon's diagnosis is rendered more accurate, the results are better.

In examining an injury by means of the X-rays we can either employ a fluorescent screen or we can take an X-ray photograph. The screen consists of a layer of cloth which has been coated with the cyanide of barium and platinum, and when this is placed in a current of X-rays with a part of the body between, those tissues which obstruct the Rays greatly will give a dark shadow on the screen, while opposite those which obstruct the Rays slightly the screen will be bright, because where the X-rays are not blocked they cause this chemical substance to become phosphorescent. Sometimes the screen is enclosed in a box which shuts out all other lights, so that the screen can be examined in daylight, but the objects can be seen



AN X-RAY PHOTOGRAPH OF A FOREIGN BODY IN THE GULLET OF A CHILD

A child accidentally swallowed a toy bicycle. By means of the X-rays accurate information of the exact position of the toy was obtained, and it was readily removed.

more clearly in a room that is completely darkened. If necessary, a surgeon can operate while the tissues are exposed to the Rays, and in this way it is possible to see that the instruments are used to the best advantage. When such a thing as a toothplate has become impacted in the gullet it may sometimes be removed with ease under the Rays, because the forceps which are used to extract it can also be seen as they approach it, and the surgeon can thus make sure that he is grasping it where it should be seized. Another way is to mark with ink the position of the object on the skin, while the screen is in use.

To obtain a photograph or, as it is better called, a "skiagram" of a part by means of X-rays, the photographic plate is placed so that the limb or the part to be photographed is between the plate and the X-ray tube; and then the Rays are turned on for a longer or shorter time. The Rays are now much more penetrating than at first, and the plates have been made more sensitive, so that the exposures to the Rays have become very much shorter. Indeed, by using extremely large currents of electricity, skiagrams have been taken in a fiftieth of a second. The photographic plate is developed in the ordinary way, and it will be a "negative" from which a "positive" can be printed. Even the condition of the heart and lung can be recognised by means of X-rays; the change in shape of the heart as it beats can also be seen, and, in fact, it has been possible to obtain cinematograph films of the heart. Very early disease of the lungs, such as tuberculosis, may also sometimes be recognised by means of a skiagram, before other methods of examination give proof of the presence of disease.

An aneurism is a dilatation of an artery, and a

common site of an aneurism is the aorta, or the large artery of the chest. In the diagnosis of an aneurism of the aorta, X-rays may prove of distinct value.

To demonstrate the form of a hollow organ like the stomach, which has a thin wall, and therefore cannot give a distinct shadow, it is necessary to introduce some substance into it which can give an X-ray shadow. Preparations containing salts of bismuth or salts of iron can be used, and it is possible to see the movements of the stomach as it contracts and expands during digestion.

It is clear from the short account I have given that even up to the present diagnosis has received remarkable assistance from the X-rays, and in the future it is not improbable that still further aid may be afforded by their use.

CHAPTER XII

THE STORY OF THE DISCOVERY OF ANÆSTHESIA

A GREAT obstacle to the performance of operations in the past was the fear of pain, for it often prevented a sufferer from consenting to an operation, even though he knew that he would in all probability be cured or at least benefited by it; and therefore one of the most important inventions in connection with Surgery during the last century was the introduction of a method by which operations could be performed without causing pain to the patient.

Anæsthesia in operations was no new idea. Homer refers to the power of nepenthe in relieving pain, and both Dioscorides and Pliny mention the use of mandragora for preventing pain in operations.

Dioscorides says that a preparation made from the root of mandragora was given to those "about to be cut or burnt by the cautery, for as they are thrown into a deep sleep they do not feel the pain." Pliny's reference to it is expressed in very similar terms, and he even states that it is possible in some cases for the smell of the drug to produce sleep.

Apuleius mentions that mandragora will cause sleep during which a limb can be amputated without the operation causing pain. The Arabian writers on medicine also describe the uses of this drug for relieving pain, and indeed in modern times a tincture

prepared from mandragora has been found to cause sleep, during which a small operation can be performed without pain.

In the Middle Ages various preparations for the prevention of pain during operations were in use; some of these were secret preparations, and therefore it is impossible to say what they contained, but the composition of those which are described shows that the chief constituents were mandragora, opium, and henbane. Later the accounts of these anæsthetic drugs do not speak so enthusiastically of them; perhaps some change in the method of preparation had occurred.

Many text-books of Surgery, even up to the end of the eighteenth century, gave various prescriptions for draughts to be taken by patients before operation; but on the whole they were very little employed, probably because they were of little use. One of the last references to the employment of these preparations occurs in a treatise on Surgery written by Benjamin Bell of Edinburgh, the seventh edition of which was published in 1801; he mentions that narcotics of every kind might be employed for the purpose of lessening general sensibility, but that nothing answered with such certainty and effect as opium, yet as opiates when given in doses large enough for this purpose were apt to induce sickness and vomiting, he seldom ventured to give them before an operation. He also states that it had long been known that the sensibility of any part might not only be lessened but even altogether suspended by compressing the nerves that supply it, but here also he appears to doubt the practicability of the method.

In 1776, Priestley discovered nitrous oxide gas, or

laughing gas, as it is often called; but it was not till 1800 that Humphry Davy found that it possessed anæsthetic properties, and this discovery came about in a curious manner. Soon after oxygen had been first separated, attempts were made to employ it and hydrogen in the treatment of disease by inhalation, and in 1798 an institution was founded in Bristol by Dr. Beddoes for the purpose of employing the inhalation of gases in the treatment of disease, and Davy was appointed its superintendent. Here he had numerous opportunities of observing the effects of the inhalation of gases, and amongst others he experimented with nitrous oxide. On the 9th April 1799, he tried it on himself, and he found that it possessed intoxicating properties, and that it relieved the pain of toothache. In 1800 he published the fact and he suggested that it might be used in operations, for he says, "As nitrous oxide . . . seems capable of destroying physical pain, it may probably be used with advantage in surgical operations in which no great effusion of blood takes place." Here we see the use of nitrous oxide by inhalation for the relief of pain and a suggestion for its employment in operations, but the suggestion fell to the ground, and nitrous oxide was not used again as an anæsthetic till 1844.

Ether (or, as it used to be called, sulphuric ether, because it was made by the aid of sulphuric acid) was known to Raymond Lully, who wrote in the thirteenth century, and later its properties were studied by several observers, but it did not receive the name of "ether" until 1730. It was only employed as a stimulant medicine, until in 1795 Dr. Pearson of Birmingham used ether by inhalation for asthma and for consumption. A few years later Woolcombe of

Plymouth employed the inhalation of ether for the relief of attacks of asthma, and then it was found that when the inhalation was continued sufficiently long the patient became unconscious.

In 1818 Michael Faraday reported that the inhalation of the vapour of ether produced anæsthetic effects similar to those resulting from the inhalation of nitrous oxide. Within the next twenty years this anæsthetic property of ether was recognised by several American physicians. Both ether and nitrous oxide were also employed occasionally to afford amusement by causing exhilaration and partial intoxication, or even unconsciousness; but the application of these properties to the relief or prevention of pain in operations did not appear to suggest itself, or at least it never advanced beyond a suggestion.

Before ether was accepted as an anæsthetic for surgical purposes, attempts were made to utilise mesmerism for the prevention of pain at operations. In the latter half of the eighteenth century Mesmer, after whom the method was named, had employed magnets in the treatment of disease, but after he had seen Gassner perform similar cures without using magnets, he discarded the magnets and evolved the idea that he possessed an occult force within him by which he could affect the nervous system of others. He met with much success in Paris in the treatment of various affections, and showed conclusively that it was possible to throw patients into a state of unconsciousness. He had many followers, and in this country the most deserving of mention was Dr. John Elliotson of University College Hospital, London. Later, James Braid of Manchester, commencing as a sceptic, investigated the subject, and under the in-

fluence of mesmerism, induced by him, several operations were performed, in some cases with complete success, but there were many failures. Even at the present day hypnotism, which is merely mesmerism under another name, is employed to a slight extent for the relief of pain, and to even a smaller extent for the prevention of pain during surgical operations. Sometimes, indeed, the anæsthesia seems to be perfect, but in only too many cases the diminution of sensibility is but slight, and in some there is no anæsthesia at all. The uncertainty of the method must prevent its use to any great extent now that we have such trustworthy anæsthetics as ether and chloroform.

Some investigations by R. H. Collier are worthy of mention as links in the chain of the utilisation of ether as an anæsthetic. He himself had experienced the power of inhaled ether vapour to cause unconsciousness when he had, as a student, attended lectures in London given by Dr. Turner at University College. Later he lectured in the United States on the value of the inhalation of the vapour of alcohol in which poppy heads and coriander had been steeped, in causing unconsciousness and freedom from pain; and in 1842 he extracted a tooth from a patient who was under the influence of the alcoholic vapour, and the patient felt no pain.

The next step forward was taken when, in December 1844, Dr. G. Q. Colton, at a lecture at Hartford, Connecticut, demonstrated the action of nitrous oxide gas in causing exhilaration and unconsciousness. While one of the audience, named Cooley, was partly unconscious under the influence of gas, he fell against a bench and damaged the skin of his arm so severely

that it bled, but he felt no pain; in fact he was not aware of the wound until he saw the blood.

Among the audience was a dentist named Horace Wells, and he was much impressed by the fact that Cooley had not felt his injury. As Wells had a carious tooth which needed extraction, he arranged with Dr. Riggs to extract the tooth, and he asked Dr. Colton to administer the gas to him.

Dr. Riggs has given a graphic account of the operation: "A few minutes after I went in, and after conversation, Dr. Wells took a seat in the operating chair. I examined the tooth to be extracted with a glass, as I usually do. Wells took a bag of gas from Dr. Colton, and sat with it in his lap, and I stood by his side; he then breathed the gas until he was much affected by it; his head dropped back; I put my hand to his chin, he opened his mouth, and I extracted the tooth. His mouth still remained open some time. I held the tooth up with the instrument that the others might see it. . . . Dr. Wells soon recovered from the influence of the gas so as to know what he was about, and said, 'A new era in tooth-pulling.' He said it did not hurt him at all."

Wells introduced the use of nitrous oxide into his dental practice and daily extracted teeth without causing pain. He was much impressed with the value of his discovery and wished to employ it for surgical operations. With this intention he went to Boston, Massachusetts, but he could not find any surgeon willing to try the experiment. He was, however, allowed to administer gas to a patient who was to have a tooth extracted at the Massachusetts General Hospital. The anæsthesia was not a complete success, because, according to Wells, the bag of gas was removed too

soon from the patient's mouth. Whatever the cause, the use of nitrous oxide for anæsthesia was discredited, and Wells was much depressed by the failure.

Ether now comes on the scene. In 1842 Dr. C. W. Long, of Jefferson, Georgia, U.S.A., removed a small tumour from the neck of a patient who had been rendered insensible by the inhalation of ether. But as this and subsequent operations in which ether was used by Dr. Long were not published till 1849, some doubt has been thrown on his claim to be considered the introducer of ether as an anæsthetic.

In September 1846 Dr. W. T. G. Morton of Boston, Massachusetts, who had been a pupil and later a partner of Wells, and had assisted Wells at the unsuccessful attempt to anæsthetise a patient at the Massachusetts General Hospital, wished to employ nitrous oxide gas for use in dentistry, but he was unable to obtain a supply, and it was suggested to him by C. P. Jackson that ether would have the same effect. Shortly after he had a suitable opportunity, and he administered ether to the patient and extracted the tooth without causing any pain. Morton wished to keep the discovery to himself, and patented it both in the United States and in Great Britain under the name of "Letheon," and a little later, on 16th October 1846, Morton administered "Letheon" to a patient at the Massachusetts General Hospital while Dr. J. C. Warren removed a tumour from the neck. The anæsthesia was perfectly successful, for no pain was felt by the patient, and great interest was taken in the matter by many doctors who were present; yet there was a little hesitation on the part of the surgeons to employ the substance, for Morton would not disclose its composition. It was, however, soon recognised

that the anæsthetic agent was ether, for the odour could not be disguised, and then its use spread far and wide. It was not long before the news came to London, and on the 19th December of the same year, 1846, Mr. Robinson, a dentist in London, removed the tooth of a patient anæsthetised with ether; and two days later Robert Liston, at University College Hospital, amputated a thigh while the patient was inhaling ether. The cutting part of the operation lasted only thirty-two seconds, for Liston did not expect much from the ether, and therefore he operated as rapidly as if no anæsthetic had been given.

From this time forward ether became widely used for the production of anæsthesia during operations, though there were a few who did not approve of the introduction of the employment of anæsthetics during an operation, but their opposition did not endure long.[1]

It is clear that to several is due the introduction of anæsthetics. While isolated employment had been made previously both of nitrous oxide and ether, yet the greater part of the credit must be given to Morton though he acted on the suggestion of Jackson. Morton petitioned the Government of the United States for a grant to him for the discovery of anæsthesia for surgical operations, but his claims were contested by the friends of Long, Wells, and Jackson, and nothing was done.

The well-known writer Oliver Wendell Holmes suggested the word "Anæsthesia." He wrote to Morton in November 1846: "Everybody wants to have a hand in the great discovery. All I will do is to give you a hint or two as to names, or the name to be applied to the state produced and to the agent.

The state should, I think, be called Anæsthesia. . . . The adjective will be anæsthetic."

The use of anæsthesia steadily extended, and the next important step was taken by Dr. James Simpson of Edinburgh. He early adopted the use of ether, but he was not fully satisfied with it, and he wished to discover some substance which would possess the advantages of ether without the disadvantages. It was not long before one or two deaths from ether had been reported. Simpson proceeded to test various liquids which he thought likely to prove useful as anæsthetics, and many subtances were suggested to him by others. In this work of testing he had the assistance of Dr. George Keith and Dr. Matthews Duncan, and it was their custom in the evening to inhale first one substance and then another, and thus to test their relative merits. In this way they had tested very many liquids, but nearly a year had elapsed before they tried chloroform. This substance had been suggested to him by Mr. Waldie, a chemist of Liverpool, who had sent him a small quantity. Chloroform had been discovered in 1831 by three separate investigators about the same time, but it had been put to little use, though it was occasionally prescribed in medicines.

On the 4th of November 1847 Dr. Simpson and his two friends started testing various liquids by pouring a small portion into a tumbler and inhaling the vapour, and after a time they tried chloroform, and as they began they described the odour as pleasant. It was not long before the three experimenters became unconscious, and when they recovered they found themselves prostrate on the, floor. Fortunately their recovery did not take long

and as Simpson came back to consciousness he said to himself, "This is far stronger and better than ether."

When they compared notes they all felt sure that a new and useful anæsthetic had been found. They made some more trials of it the same evening, and they were so satisfied with the results that they did not part till a late hour.

A week later Simpson read a paper on the subject before the Medico-Chirurgical Society of Edinburgh, and shortly after this he arranged to administer chloroform to a patient for an operation. However, he was unable to be present, and after a little waiting the operation commenced without any anæsthetic. At the first touch of the knife the patient died. It must be regarded as fortunate that Simpson was not present to give the chloroform, for if he had been there and the patient had died, the death would certainly have been ascribed to the chloroform. However, a week or so later chloroform was used with perfect success in three cases.

In the British Isles ether was soon replaced as an anæsthetic by chloroform, but a change in this matter took place about 1868, and since that time there has been a partial return to the earlier anæsthetic. At the present time in England ether is extensively employed, though in Scotland chloroform still is the more widely used. In the United States of America ether is still preferred, especially in the Northern States.

It is very difficult to administer ether in tropical climates, as in India, because ether evaporates at the comparatively low temperature of 96° F., therefore in most hot climates such as India ether is hardly

ever employed, chloroform being used as the regular anæsthetic; the boiling-point of chloroform is 140° F.

Although nitrous oxide was the first anæsthetic to be employed, its use was soon discontinued, but in 1863 it was reintroduced by American dentists as the most convenient anæsthetic for such short operations as the removal of a tooth. It is an excellent anæsthetic, for it is capable of producing complete insensibility; it is very safe in administration, rapid in its action, and patients recover quickly from it; moreover, seldom does it give rise to any unpleasant after-effects. But the shortness of the duration of the anæsthesia which it produces limits its use to brief operations, such as removal of a tooth, the opening of an abscess, or the loosening of stiff joints. Within recent years, however, it has been possible to give the gas mixed with oxygen, and it then becomes suitable even for prolonged operations; but used thus it is very expensive. Although other general anæsthetics have been introduced from time to time, and various mixtures of anæsthetics have also been employed, they are but little used at the present day, and the field of general anæsthesia is practically monopolised by ether, chloroform, and nitrous oxide.

As to the risk of anæsthesia, it may be said that while putting a patient into such an unnatural condition as complete anæsthesia and complete unconsciousness can never be wholly free from danger, yet in skilled hands the risk is small; and it is well worth while to incur that risk in order to escape the severe pain of an operation.

Another method of preventing a patient suffering pain during an operation is local anæsthesia, and of

this there are two kinds. In the first form the part is frozen, for if a part of the body be frozen it becomes completely anæsthetic. J. Arnott introduced this method in 1848, and he employed a mixture of ice and snow. This is effective, but it is not always available. A much more convenient method was devised in 1866 by Sir Benjamin Ward Richardson, who invented an apparatus by which a fine spray of ether, highly rectified, was thrown upon the part. The ether evaporates rapidly, abstracting so much heat from the tissues as to freeze them, and the skin soon becomes white and hard. This method is still widely employed, but ethyl chloride is usually employed in place of ether, as it freezes the tissues more quickly. In the other method of local anæsthesia the nerves of the part are paralysed by the use of a suitable drug. Cocaine was introduced in 1884, and it was at first much used, and indeed is still often employed, but many substitutes, such as Eucaine, possess advantages over the original substance, and therefore at present they are more widely used. A solution of one of these substances, of suitable strength, is injected underneath the skin, and in two or three minutes the part will have lost all sensation. These drugs are especially valuable in many operations on the eye and the mucous membrane of the mouth, throat, and nose, for they produce their effect even if they are merely placed on the surface, as they do not need to be injected.

Within the last few years a third method of anæsthesia has been employed called "spinal anæsthesia." In this method a solution of cocaine, or more commonly of one of its substitutes, is injected into the back so that it is close to the spinal cord. In this

way the nerves of the lower half of the body have their sensation paralysed at their roots, so that, although the patient is fully conscious, he knows, by his sensations, nothing of the operation which is proceeding. It is clear that the method is not applicable to operations on the head and neck, and it has not as yet been widely employed in this country, but in France many surgeons seem to prefer it.

CHAPTER XIII

ANTISEPTIC SURGERY

In order to appreciate fully the enormous progress which has been made in surgery since the introduction by Lord Lister of the antiseptic method, it is essential for the reader to know something as to the results which were obtained previously. We know little of surgery before the fifth century B.C., but we find a very full account of its position at that age in the works of Hippocrates and his immediate followers, and from those writings we are able to see that during the many centuries which have elapsed surgery has made great and steady advances. One of the more serious obstacles to the progress of surgery had been the danger of loss of blood, but ultimately the use of the ligature for tying blood-vessels had become fully established in the latter half of the eighteenth century, and when the danger of hæmorrhage was removed progress was at once visible. Another great obstacle to the extensive employment of operations had been the fear of the pain necessarily incurred by the patient; and it must not be forgotten that a great deal of the shock following an operation was occasioned by the pain, and this also had much harmful effect. These hindrances to operation which depended on the unavoidable infliction of pain were removed by the

introduction of anæsthetics, as I have described elsewhere, in Chapter XII.

There remains yet a third difficulty which had to be overcome before surgery could enter into its full heritage. In the days before the introduction of antiseptic surgery, no surgeon could feel sure of his results; however much care he may have taken in the planning and performance of the operation itself, however completely he may have prevented the loss of blood, he could not foretell with any approach to certainty whether the patient would recover from the operation or die as the result of its performance. After an operation the patient might go on well for a day or two, but then, even in the most favourable case, the wound which had been produced began to secrete a large amount of matter or pus, as it is technically termed. Then even in favourable circumstances it would heal up very slowly, generally taking several weeks in the process, and for the greater part of this time fever and pain were present. This was a favourable result, or so it was considered then; but unfortunately even this measure of success was not always attained. Only too often feverish attacks would come on a few hours after the operation; the fever would increase from day to day, and in a few days' time death would result from blood-poisoning. Sometimes inflammation would attack the skin surrounding the wound and erysipelas would appear, and not unlikely lead to a fatal issue. I have mentioned only two of the severe complications which might result, but really there were many ways in which death or a prolonged illness might follow the performance of an operation.

Inflammation might appear round the wound, and

gangrene might follow it, so that what was at first merely a small incision might become within a few days an extensive sore; and if these results were likely to follow incisions made for the purpose of removing a growth or with some such object, similar results were even more likely to follow accidental wounds. A mere puncture with a sharp instrument, a stab with a knife, might be followed by the most severe consequences, even by death itself, though no important structure had been wounded. Occasionally, indeed, wounds healed up at once "by first intention," as it is technically called; but this was a result that did not often occur, and it was not encouraged, because the surface might heal and yet pus might form in the deeper parts of the wound, and this would need another operation for its removal. The most curious point about the results was that the surgeon could not say beforehand which case would heal by first intention and which would be followed by great inflammation, by sloughing, or by death. Sometimes abscesses would form in other parts of the body, and to this the name of pyæmia was given, for it was thought that somehow the pus from the wound had made its way into the blood; and then severe rigors or shivering fits would assail the patient, or profuse sweats might weaken him still further.

It was recognised by surgeons in those days that a large proportion of the cases must suppurate, that is to say, must form pus, in ordinary circumstances, but occasionally epidemics of sepsis arose, especially in hospitals, and case after case would suffer from one or other of the septic diseases. Sometimes every case in the ward on which an operation had been performed would develop erysipelas; sometimes case

after case would be attacked with pyæmia, and yet the surgeon was unable to say why these diseases appeared, or why they were absent. Sometimes it seemed as if the season of the year might be responsible, and many were inclined to attribute to the spring a specially harmful influence; sometimes, however, epidemics would show no predilection for any particular season. Every surgeon had some theory to account for the occurrence of these diseases, and some method to prevent their appearance, but for the most part their efforts appeared to be in vain.

At last it was recognised that erysipelas and its allies did not appear in all circumstances. They appeared much more frequently in hospitals than in private practice, and they were certainly much more common among patients dwelling in towns than among those treated in the country. Even in the wards of the same hospital great differences occurred in the relative frequency with which cases of septic disease appeared in the different wards. After a time it was recognised that the overcrowding of a ward for more than a very short time was fairly certain to be accompanied by the appearance of one of these diseases, and especially by that spreading form of ulceration which was called hospital gangrene. In wars, when large numbers of the wounded were gathered together under one roof in buildings ill-adapted for the care of patients, hospital gangrene almost always appeared, though it was hardly seen at all amongst the wounded who were treated in the open air. The frequency of these diseases may be gathered from a few figures. From some statistics collected by Sir John Erichsen relating to 631 cases of

amputation before antiseptic surgery was introduced, it appears that no less than 86 died from pyæmia alone, and in all 239 deaths occurred. It must not be forgotten, however, that "shock" was responsible for ten per cent. of these deaths; but when we put aside these, the remaining cases, more than two hundred in number, died from septic causes, that is to say, causes which with our present knowledge we may reasonably look upon as preventable. Of the cases infected by some septic disease the deaths varied between eighty and ninety per cent. Although the surgeons of those days could not assign to any known cause the septic complications of their operations, yet some among them, by special attention to detail, were able to obtain results superior to those of many of their fellows. Separation from other patients, and country air, were definitely advised, and cleanliness in everything connected with the operation certainly improved the results. Yet still, it was thought that suppuration, that is, the formation of pus, was a natural concomitant of a healthy healing wound.

I have mentioned that sometimes it happened that the patients in some wards of a hospital were much more liable to be affected with septic diseases than the patients in other wards, and this fact, combined with the observation mentioned above, that septic diseases were much more common in hospitals than in private houses, led to the suggestion that hospitals should be merely temporary structures, and that after existing for a few years they should be pulled down and rebuilt. If surgery had thus arrived at the position that, in spite of the great surgical skill and manual dexterity of operators, the results were so uncertain that much hesitation was felt in operating on any case

but those where operation was essential, it was evident that some unknown factor was at work.

In this condition was surgery when Lister devised the antiseptic method.

Joseph Lister was born in 1827. His father was a man of some eminence in science, and he was especially worthy of remembrance in connection with the perfecting of the compound microscope. Lister entered as a student of medicine at University College, London. In the epidemics of hospital gangrene which he saw at University College Hospital he had an opportunity of observing its mode of spread, and he was satisfied that it was not constitutional in origin, but due to some local cause.

After working as house surgeon to the celebrated surgeon Syme of Edinburgh, Lister was appointed surgeon to the Royal Infirmary at Glasgow. About this time Pasteur was showing that all forms of fermentation were due to the presence in the fermenting liquid of minute bodies, and that if care were taken to exclude these micro-organisms from the fermentable liquid no fermentation occurred. It was an act of genius to perceive the analogy which exists between the changes which occur in the fermenting liquid and suppuration in an open wound. Lister, seeing this analogy, was led to believe that if living germs could be excluded from the wound no suppuration would occur. He perceived that these germs might come from the air, from the skin of the patient, from the surgeon's hands, and from the instruments employed; but he was inclined to look upon the germs in the air as of special importance. We know now that he overrated the importance of the germs in the air; nevertheless, the extra precautions he took

to exclude the germs from this source were only unnecessary and did but little positive harm. The form of wound that Lister chose for his first attempt to carry out in practice the theory he had formed was a compound fracture. To appreciate fully what he did, it is essential to understand what a compound fracture is. When a bone is broken but no injury is done to the skin, or rather there has been no wound of the skin communicating with the fracture, the condition present is called a simple fracture. In a simple fracture, if the fragments of the bone are placed in position and kept so, they will unite in a few weeks without any difficulty. There will be no fever, no real inflammation around the broken bone, and in fact, except for the discomfort of having a limb in splints and for being unable to take exercise, the patient is very little the worse for his broken bone.

When, however, at the time of the breaking of the bone the skin in the neighbourhood of the fracture is torn or cut or pierced by one of the fragments, the condition is called a "compound fracture." Formerly a compound fracture was very much more serious than a simple fracture. Instead of healing swiftly and certainly as a simple fracture would, a compound fracture was always accompanied by a great amount of inflammation. The skin around the wound leading down to the fracture quickly became reddened, hot, and painful, and from the wound pus soon began to pour out. At the same time the patient was seized with fever. His temperature would run up many degrees; severe shivering fits would attack him; he was bathed from time to time with profuse sweats, alternating with acute febrile attacks. Various forms of blood-poisoning frequently occurred. Abscesses

might develop in different parts of the body; erysipelas might invade the neighbourhood of the wound; and weakened by these various assaults, worn-out by the high fever and the profuse sweating, in only too many cases the patient with a compound fracture died.

Even if the patient eventually triumphed over these septic complications, it was often only by the sacrifice of a limb that he was able to overcome the attacks.

This striking difference between the two forms of fracture forced itself on the attention of the surgeon at a very early date, and, so far as could be seen, the only difference between the two injuries was that in the case of a compound fracture the air had access to the broken bone, while in the other no air could get to the fracture. We now know that it was not the access of air which was responsible for the harmful results met with in compound fracture, but that they were due to the fact that through the wound of the skin and other soft parts the germs from outside made their way down to the site of the fracture. It is true that some of these germs are introduced by the air. Sometimes the fragments of bone may protrude and become contaminated, but a still greater risk arises from the fingers and instruments of the surgeon which are used to examine and replace the broken pieces of bone.

It is therefore clear that the results of compound fractures were extremely bad, and very much worse than the results of simple fractures. Lister thought that it would be well to commence his attempts to prevent the entrance of germs into the wound by dealing with a compound fracture, for he felt that the results could not be made worse even if the attempt failed, but if it should succeed the results would be

enormously better. In looking for a suitable antiseptic, Lister thought of carbolic acid, for he was acquainted with its very great efficiency in deodorising sewage, and it was evidently a very powerful antiseptic. In the first case the undiluted acid was applied to wash out the interior of the wound as soon as the patient was seen, and then it was painted daily over the surface until the skin wound healed. Success followed the attempt, and it was not long before Lister was able to announce that, treated by his antiseptic methods, a compound fracture would heal in as simple and kindly a fashion as any simple fracture. At first he used the carbolic acid in an undiluted form, but he soon found that it caused an unnecessary amount of pain and damage to the tissues, and he discovered as the result of experiment that equally beneficial results were obtainable by weaker solutions. Although he applied the carbolic acid to the interior of the wound on the first occasion, he did not do so when the wound was dressed, for he held that the first application had been sufficient to destroy any germs that were present, and that subsequent applications would serve only to irritate the tissues.

Lister made many experiments to discover the best method of application of the acid and the best method of excluding germs from the wound; he was not satisfied till he had found a method on which he could rely. The same antiseptic procedure was applied to operation wounds with the same happy results. The skin of the patient was carefully cleansed and wiped over with a solution of carbolic acid, and the hands of the surgeon were treated in a similar way, while the instruments to be employed in the operation were allowed to stand for about half-an-hour in a

solution of the acid. Lister attributed great importance to the air as a vehicle of germs, for he thought that germs, thousands of which are floating about suspended in the air, fell into the wound during the operation. It is true that this occurs, but we now know that he over-estimated the danger from these air-borne germs. Most of the bacteria infecting a wound come from the skin of the patient, the hands of the surgeon, or the instruments employed. To deal with the aerial germs Lister invented a carbolic spray, which was an apparatus for sending out by means of steam a fine spray of carbolic acid, which covered the whole area of operation. We now know that the spray was unnecessary and that occasionally it did some harm, and the absence of necessity for the use of the spray was first pointed out by Lister himself, and it has long been abandoned.

This is a brief description of the introduction of the antiseptic method, and it is of interest to note how it was received. With regard to Lister's results there could be no real dispute. His wards in the Glasgow Infirmary were probably the least hygienic in the whole building, but the results which he was able to obtain after the employment of the antiseptic method far surpassed those attainable even in the purest country air. The publication of his method met with a very mixed reception. A few surgeons—for at first his imitators formed but a small minority—adopted his method and used his precautions, and according to the faithfulness with which they followed his instructions they attained results which could be compared with those of Lister himself.

One reason why the process of adoption of the antiseptic method was not very rapid in this country

was that many surgeons appeared to imagine that the employment of carbolic acid was the essential point in Lister's treatment. He had devised a principle of treatment, and they thought that he had introduced a drug. It is easy so to employ carbolic acid as to do but little good, and, in fact, its reckless use may easily lead to harm. Progress, however, was made, and gradually almost all surgeons adopted the antiseptic method. In other countries the introduction of Listerism varied greatly, but it must be acknowledged that in Germany the new method was more rapidly appreciated than in Great Britain itself; France, also, was not slow to adopt it. It is interesting to note that when Lucas-Championnière wished to employ the antiseptic method in Paris he was compelled to provide the dressings at his own expense, for the hospital authorities would not consent to defray the cost; and when he wished, at the outbreak of the war with Germany, to take some carbolic acid with him to the seat of war, his chief would not consent.

Statistics showed clearly the very great and rapid improvement effected in the practice of those who conscientiously and thoroughly practised the antiseptic treatment. The results were astonishing. With no change in any other particular, with the same class of patient, in the same wards and with the same operators, and for the same diseases and injuries, the death-rate underwent a great diminution. The change produced did not consist only in the lessening of the death-rate, though that was the point of most importance, but in those who recovered the duration of the recovery was much reduced. Instead of a man taking many weeks or months to recover

after a severe operation, he would be well within a fortnight; and even the reduction in the amount of pain felt by the patient must not be left out of account, for when a wound heals by first intention much less pain is felt, and it requires much less frequent dressing.

When a limb was crushed, as by a cart-wheel, with extensive injury to the bone and soft parts, it was far wiser in the pre-antiseptic days to amputate the limb early, rather than to attempt to save the limb and to fail, for that would probably mean the death of the patient. It was soon found by those who followed the antiseptic teaching of Lister that it was possible to obtain rapid healing in many of these cases of severe injury, so that it was justifiable for the surgeon to attempt to save a damaged limb which without antiseptic precautions he would have felt compelled to amputate at once.

When the surgeon found that he could almost guarantee the healing of a wound by first intention, he felt at liberty to operate more frequently and more freely than he had dared to do in earlier days. So it came to pass that the extent and frequency of operations increased. Many conditions in which formerly the effect of the interference of the surgeon might have been even more disastrous than the results following merely medicinal treatment were now submitted to operation with incalculable benefit to the patient. Modern surgery may indeed be said to date from Lister's discovery.

We have seen that many of the methods and precautions adopted by Lister in his early operations were discarded as he gained experience with the

practice of his method. The carbolic spray was found to be unnecessary. At first strong solutions of carbolic acid were employed with it, and many surgeons used weaker and weaker solutions until the spray contained little more than water and yet the results were in no wise less satisfactory, until when the spray was done away with entirely the results were equally good.

The elaborate dressings of gauze and mackintosh advocated at first were found equally to be unnecessary, and a simpler dressing was employed. It was then recognised more fully, that in an operation on a part where no wound had previously existed and no abscess was present, it was needless to introduce carbolic acid or any other antiseptic into the wound to destroy the germs, for there were no germs there to be destroyed. At first carbolic acid was used to sterilise the instruments, but later it was recognised that boiling was a more rapid and perhaps even more efficacious method. The dressings to cover in the wound at first contained carbolic acid; then Lister introduced sal alembroth gauze, which contained perchloride of mercury or corrosive sublimate; and later still he employed cyanide gauze containing a double cyanide of mercury and zinc, which was less irritating than either of the preceding dressings. Many surgeons, however, came to believe that it was unnecessary to have any antiseptic in the dressing, for in the study of bacteriology it has long been recognised that germs cannot pass through a layer of cotton-wool one inch thick, and therefore germs could not pass through a dressing consisting of many layers of gauze and wool. Therefore a dressing was introduced consisting merely of plain gauze and

cotton-wool, and it was found that this dressing was quite capable of preventing the entrance of germs from the air; but it was essential that the gauze and wool should themselves be completely free from germs, or "aseptic" as it is termed. These dressings now are rendered aseptic either by steaming or by baking. So that, in the most recent form of surgery, chemical antiseptics are largely excluded from use, none being introduced into the wound, the instruments being sterilised by heat, and the dressings also. It is now recognised that so long as the surgeon takes care not to introduce any germs into the wound, if no sepsis has been previously present, the tissues themselves will be capable of dealing with the few that may accidentally make their way into it. Therefore modern surgery is often spoken of as "Aseptic Surgery," yet even at the present day it is not possible to sterilise by heat the skin of the patient or the hands of the surgeon and his assistants. It is still necessary to employ chemical antiseptics to render the skin of the patient as free from germs as possible. In the case of the hands of the surgeon and his assistants it has been found extremely difficult, and in the opinion of some impossible, to destroy absolutely every germ on them, though, with thorough washing and prolonged soaking in an antiseptic solution, an approach to perfect asepticity can be attained. An attempt has been made to evade this difficulty in the case of the hands by wearing rubber gloves which have been rendered sterile by boiling, and it is probable that this is a useful detail in many operations, though, as the rubber gloves may be torn or pierced by a needle during the course of an operation, just as much care should be taken to sterilise the hands before

donning the gloves as if no gloves were to be used. It is customary to term the most modern surgery "Aseptic Surgery," as I have mentioned, but it must not be imagined that aseptic surgery is at all antagonistic to or opposed to antiseptic surgery; it is merely the latest modification of the application of the antiseptic principle enunciated by Lister himself, that every effort must be made to exclude germs from wounds. On the whole, it may be said that the practice of most surgeons of the present day consists in a judicious application of the principles of antiseptic surgery, modifying the practice according to the requirements of the individual case, but recognising that the tissues of the body are for the most part free from germs, and that a wound made in tissues free from germs cannot be improved by the introduction of an antiseptic, which, if it has any action at all, must only cause unnecessary irritation. When a wound is already septic the case is altered, and here the judicious application of antiseptic substances may exert a very favourable effect.

The success of antiseptic surgery is attested by forty years of an ever-widening application. It is probable that the lives saved by Lister's teaching must now be numbered by millions, and, in addition, operations have caused far less pain to those who have had to submit to them. Of all the many blessings which the medicine of modern times has conferred on the human race, none can compare with antiseptic surgery.

CHAPTER XIV

THE ARREST OF HÆMORRHAGE

To stop bleeding, whether it be the result of an accidental injury or whether it come from a wound intentionally inflicted in an operation, has always been one of the more important functions of the surgeon. Even amongst savage races we find various methods adopted for the purpose of arresting hæmorrhage, and some of them correspond very closely to those which were employed by surgeons in civilised countries during past ages. It is needless to elaborate the necessity for rapidly putting a stop to bleeding. Every drop of blood contains many millions of red corpuscles, and it is of the greatest importance that they should not be lost to any great extent. There are some five million red corpuscles in every cubic millimetre; and in a cubic inch of blood there are about eighty thousand millions of red corpuscles. They are essential because they carry oxygen from the lungs to all parts of the body, and this oxygen is absolutely necessary to the life and action of the tissues. Therefore, if they are greatly diminished in number, life cannot continue, and when many of them have been lost weeks or months may elapse before the loss is regained.

In health many, many thousands of red corpuscles are manufactured every second; but after great hæmorrhage they do not seem to be made so rapidly

as in health. The whole body contains about one-thirteenth of its total weight of blood, so that if we may say an average human being weighs 130 pounds, there will be about ten pounds of blood in the body, that is to say, about a gallon. It has been calculated that about a third of this can be lost and yet life will be maintained, but there is risk that even a smaller loss than this may have a serious if not fatal result.

I have mentioned these facts in order to show how extremely important it is that hæmorrhage should be arrested early.

Hæmorrhage has a tendency to arrest itself. When blood is shed it soon begins to clot, as every one knows; and this marvellous clotting power of blood is due partly to the liquid part of the blood but partly also to the white corpuscles, which appear to sacrifice themselves by becoming disintegrated and so assisting in the clotting of the blood. If it were not for this coagulating power of the blood, even small cuts would continue to bleed without ceasing and would lead to death. There were three main methods employed in early stages of civilisation for the arrest of hæmorrhage, and we find two of them still in popular use even at the present day. Of these two methods the first acts by assisting the coagulation of the blood. If blood be received into a vessel it will clot much more rapidly if the vessel contains any finely divided particles or an irregular surface. This fact has been utilised to assist in stopping hæmorrhage, for we find that certain leaves have been employed, such as those of the "wound-wort," which are covered with many fine downy hairs, and the Matico leaf, which has a very rough surface. The blood becomes entangled, as it were, in these irregularities, and clots

rapidly. This is the principle on which cobwebs are employed to stop bleeding, for the many fibres of the cobweb favour coagulation. It may be as well to mention that cobwebs are very unsuited for a dressing to be applied to a bleeding spot, as they are always very septic, and many deaths have occurred from their application to wounds, especially from infection with the tetanus bacillus. Cotton-wool acts similarly in assisting in the coagulation of the blood, and if aseptic it may be useful for small wounds. Another method by which the arrest of hæmorrhage is effected is by the application of certain substances called styptics, which possess the power of contracting the blood-vessels, so that the openings become slightly smaller and therefore more easily closed by blood-clot. This method, though effective when the vessels wounded are not large, is rarely used by surgeons at the present day, for in most cases the styptic damages the tissues greatly and tends to prevent them healing by first intention. There is, however, one substance recently introduced into surgery which has a wonderful power of contracting the smaller vessels, and thus of arresting hæmorrhage, without damaging the tissues at all. Above each kidney is a small gland called, from its position, the suprarenal body. We know but little of its function, but it is certain that an extract made from it can contract the small blood-vessels and thus can assist in stopping bleeding. Therefore at the present day surgeons sometimes employ a solution of the extract of the suprarenal gland to assist in stopping the oozing from the smaller blood-vessels, but it is of very little value in arresting the hæmorrhage from a blood-vessel of even moderate size.

The third agent which seems to have been em-

ployed in early times for the purpose of stopping hæmorrhage was the cautery. A piece of iron heated to a red heat was applied to the bleeding spots, or drawn across the surface of the wound. This method was certainly efficacious, and occasionally it is employed even at the present day. It has, however, one great disadvantage; for the burnt surface cannot heal by first intention, it is very liable to become septic, and when the burned sloughs are thrown off it is not at all rare for the bleeding to recommence. Sometimes the heat was employed in another way, as after a gunshot wound the raw surface was treated with hot oil, which certainly had the effect of putting a stop to any hæmorrhage present, but it caused severe pain for many hours afterwards. The tale has often been told how Ambroise Paré, who was surgeon to Francis I. of France, found himself after one engagement without any oil to apply to the wounds, so that it was with much misgiving that he treated his patients with a simple dressing. To his surprise, those patients treated with a simple dressing passed much less painful nights than those who had been submitted to the then orthodox treatment of boiling oil. The improvement in the general condition of the patient was so great that he determined to employ this method in future, and this was made easier from the fact that he re-introduced the use of the ligature for tying blood-vessels. The ligature could not be called a new method in Ambroise Paré's time, for it had been known to and employed by Galen fourteen centuries earlier, and it had been used for many years after Galen's day; but it had practically been forgotten until Paré brought it forward again and employed it widely, and showed that it was a very satisfactory

method of preventing hæmorrhage from the larger arteries during and after amputation.

The ligature remains to-day the most simple and the most trustworthy of all our methods of stopping bleeding. Until the introduction by Lister of the antiseptic method of treating wounds, the silk or thread with which a blood-vessel was tied was left long, so that when the ligature was loosened by suppuration it might be pulled out; this occurred a week or so after the ligature had been applied, and about the time when the ligature came away it was not unusual for hæmorrhage to come on again; this was called secondary hæmorrhage, and when it appeared it gave much trouble, for it was often very difficult to stop. Since the introduction of antiseptic surgery it has been possible for the surgeon in almost all cases to ensure the absence of germs from the wounds, and therefore, as suppuration does not occur, secondary hæmorrhage is now almost unknown, and the surgeon may with confidence cut the ends of the ligature short and leave it in the wound.

There has been much improvement in the material of which ligatures are composed. Formerly thread was employed, and before use it was well waxed. These ligatures were not aseptic, and it is hardly necessary to say that no precautions were taken to keep them aseptic; in fact, at one time it was customary for the house-surgeon to put the ligatures in his button-hole, so that they could be conveniently withdrawn one by one as they were required. It is not surprising, therefore, that in those days the ligatures always set up suppuration, which continued until they were removed. At present silk and catgut are mainly used, and there is some difference of

opinion as to which is the better of the two. Silk is more easily sterilised, for it can be boiled; but it is absorbed very slowly, and therefore sometimes it acts as a foreign body and gives rise to inflammation, even though it is quite free from germs. Catgut has the great merit of being absorbable, and by varying the method of preparation the rate of absorption can be adjusted within certain limits, so that the surgeon can, at his choice, employ one piece of catgut which will be absorbed in ten days, or another piece of catgut which will resist absorption for six weeks.

There is no doubt that this absorbability of catgut renders it desirable for many purposes, for if it is absorbed it can never cause irritation later on. Catgut, however, has the very great disadvantage that it is naturally a septic substance, and that it requires very great care to render it free from germs, for it will not stand boiling in water. These difficulties can, however, be overcome, and catgut that has been suitably prepared is a very good material for ligatures and for sutures.

The most valuable method for the temporary arrest of hæmorrhage after an injury, or for the prevention of loss of blood during an operation, is undoubtedly the tourniquet. This in its original form consisted of a band passing round the bleeding limb, and into the loop a short stick was inserted by which the loop could be tightened when the stick was twisted round, and it was called a tourniquet because of this twisting.

Many forms of the instrument have been invented from time to time, and each has some merit. The most generally convenient form at present is one consisting of a piece of rubber-tubing with very thick

walls. This is made to encircle the limb at least twice, and then it is fastened so that it cannot come undone. This form was introduced by Esmarch, the celebrated German surgeon. It is especially useful for accidents, for it is light and so it can be easily carried about, and it can be readily and quickly adjusted even by those who are unacquainted with anatomy and therefore do not know where the large blood-vessels of the limb are to be found.

With some other forms of tourniquet it is necessary to adjust a pad exactly over the main artery of the limb, and therefore they are more difficult to apply. Esmarch's tourniquet is very widely used, and is of very great value.

In all hæmorrhages the faintness which the patient feels from the loss of blood tends to make him fall down so that he lies in a horizontal position, and this is really the best position for a patient losing blood, because then the heart beats less forcibly and much less frequently, so that the blood has a greater chance of clotting at the mouths of the vessels, and the hæmorrhage may cease spontaneously. Well-meaning bystanders, in their excess of zeal, appear to have a natural inclination to raise the patient into a sitting position on the ground or on a chair, and unfortunately these well-meaning efforts are generally productive of harm. It is far better to let the patient lie at full length on the ground. If the hæmorrhage is coming from an arm or a leg, that limb may be raised, and this may suffice to stop the hæmorrhage.

I have mentioned that a cautery at a red heat has been employed to stop hæmorrhage; but a much lower temperature is also sometimes useful. If water at a temperature of about 120° Fahrenheit be applied

to a bleeding surface, the vessels will contract, and all the bleeding will stop that comes from small vessels. This temperature can be guessed fairly well, for the water is just as hot as the hand will bear. Water cooler than this, say at 100° Fahrenheit, will increase the bleeding. Cold will also control bleeding, but not so thoroughly as very hot water, for as soon as the cold is removed the vessels relax and the bleeding is likely to recommence. The cold may be conveniently applied by the use of an ice-bag, which is a rubber bag containing pieces of ice.

CHAPTER XV

SHOCK

THERE are three great causes of death after operation; these are sepsis, hæmorrhage, and shock. In Chapter XIII. I have described the wonderful results of the introduction of antiseptic surgery; I have shown the marvellous effect the employment of the methods introduced by Lister had on the mortality of wounds, both accidental and occurring after operations. In Chapter XIV. I have described the methods employed to diminish the loss of blood during operation; I have shown that with modern appliances, some of them indeed very old though recently reintroduced, surgeons have been able almost completely to put an end to mortality from hæmorrhage occurring in the course of an operation. Only one great cause of death remains, and that is shock. Though much has been done of recent years to combat it, even now it cannot be said that we have entirely succeeded in abolishing shock during operations.

Shock is a frequent cause of death after accidents as well as after operations. When a man receives an extensive yet superficial burn and dies within a few hours his death is almost certainly the result of shock. When a limb is crushed by a train, and death comes within the first few hours, it will rarely be due to hæmorrhage; it will never be due to sepsis, but nearly always it will be the result of shock. Shock is

a convenient name for the deadening effect on the nervous system caused by a severe injury. The whole central nervous system becomes, as it were, powerless. The feeble pulse and the pallid face show the weakness of the action of the heart, and the shallow breathing indicates at what a low ebb are the nervous functions. Complete unconsciousness may be present, or in response to a spoken word the eyelids may be raised and a few half-audible words may be uttered, but the eyelids quickly droop again and the patient relapses into his former condition. In a severe case, unless the reaction comes, and comes soon, death must ensue.

It will be clear that the amount of shock will depend in the first place on the severity of the injury inflicted. A crushed finger, or an operation on the hand, will cause very much less shock than the laceration of a whole limb or an amputation at the shoulder. If two limbs require to be amputated at the same time the chance of recovery will be materially diminished. In many cases the effect of hæmorrhage will add greatly to the amount of shock, and sometimes the word "collapse" is used, when shock is accompanied by severe hæmorrhage. It is obvious that the greater the injury to a part, the greater the shock that will follow, and even if no hæmorrhage be present intense shock may result.

The mental condition of the sufferer at the time of the infliction of the injury has a material influence on the severity of the shock produced. An injury inflicted on a man already depressed mentally and in a low state of health will have far greater effect in causing shock than will the same amount of physical disturbance in a man healthy both in mind

and body. The difference may be sufficient to turn the scale. Every one knows how excitement will enable a man to bear easily an injury which otherwise might have produced no small amount of shock. In the excitement of battle very severe injuries have been endured ; even a limb has been torn away, and yet no pain may have been felt, and no shock may have been inflicted. It must not be forgotten that the depressing effect of pain has no small share in the production of shock. This is shown in many ways, but especially is it clear from the fact that anæsthetics have been found not only to do away with the feeling of pain but also to go far to lessen the amount of shock produced. The most striking effect of shock is its action on the circulation. The pulse becomes extremely feeble, often barely perceptible, and this effect is brought about in two ways ; first, the heart is weakened by the violent impression on the nervous system due to the injury, and secondly, many of the large veins of the abdomen are, as it were, paralysed, so that they dilate and contain so much blood that the remaining vessels are only partly filled ; as a result the blood pressure undergoes an enormous fall, so that the whole body, especially the nervous system, is insufficiently supplied with blood. Naturally the result will be far worse, if at the same time a large amount of blood has been lost by hæmorrhage. This is not the place to describe in detail the treatment of the condition, but two methods which have been adopted to deal with the great fall of blood pressure in shock may be mentioned. The first method is to introduce into the blood-vessels of the patient some blood from another person. At one time, indeed, attempts were

made to utilise the blood of sheep or other animals, but such attempts were foredoomed to failure because the blood of man and of sheep cannot be mixed without the destruction of the red corpuscles of one or both. Transfusion of the blood of one person into the veins of the other is very seldom done nowadays, though it is not very uncommon in novels. The objections to it are, first, that it is not at all easy to get a suitable person to supply the blood; secondly, if any real good is to be done the quantity to be transfused must measure at least half a pint; thirdly, the blood may clot during its passage from one person to the other or after it has entered the veins of the recipient; and lastly, the giver of the blood often has a long and tedious convalescence before he regains completely his former health. Direct transfusion, as this method is called, has been almost completely replaced by the transfusion of saline solution. A solution of common salt is made of a strength which has been found not to damage the corpuscles of the blood. This is prepared with water free from germs and it is heated to a temperature several degrees above the temperature of the body, so that it may not produce any chilling effect. It is then slowly injected into a vein of the patient. If it is injected sufficiently slowly large quantities may be introduced, and as it is obtainable almost everywhere it has come to be a valuable method of treating shock readily available in emergencies. Even so large an amount as several pints has been introduced with benefit. In suitable cases, if due precautions are taken the results are often marvellous, so that some persons even moribund have been brought back to life. The same saline solution may

also be injected into the tissue under the skin; this method is simpler than the intravenous method, and it is safer, but its action is not so rapid.

With modern precautions it is possible to eliminate shock from operations to a very great extent, though much still remains to be done.

CHAPTER XVI

WHAT MODERN SURGERY CAN DO

In previous chapters I have explained that the three great difficulties in the past in the more important operations of surgery were sepsis, hæmorrhage, and shock. Sepsis is now, thanks to the work of Lord Lister, no longer a necessary accompaniment of every surgical operation; for with care and attention to detail it has become almost possible to guarantee the absence of germs from the field of an operation. Further, many methods have combined to render the loss of blood at operations extremely small, and lastly, we can to a very great extent control the amount of shock which follows an operation. Thus the main dangers of an operation have been greatly reduced in severity. Armed with the weapons which the progress of surgery has put into his hands the surgeon of to-day can undertake and bring to a successful conclusion operations which not very long ago would have been considered beyond the bounds of possibility. An amputation even of a whole limb can now be carried out with a very small risk of a fatal ending, and in fact death hardly ever follows such an operation, unless it has been performed soon after a severe accident, which has rendered the operation necessary. In such cases the death is to be attributed mainly to the original injury, though necessarily the shock of the operation, however

rapidly, however skilfully performed, must have contributed, in some degree, to the fatal ending.

In a matter such as this a surgeon will often find it difficult to decide as to the best time for an operation. If performed at once, the shock of the operation is superadded to the shock of the injury, while if the operation is postponed, the loss of blood by oozing may be serious and the chance of sepsis definitely increased. The amount of shock resulting from an injury varies greatly in different cases even when the amount of damage done is much the same. It may be mentioned that the shock in cases of railway injuries is usually exceedingly great, for the violence far surpasses any other form of injury to which we are liable. Injuries to the head and to the heart have very much shock, and as a rule the greater the extent of tissue injured, the greater the amount of shock. There are, however, many exceptions to this general rule, and many cases occur in which very severe injuries have been inflicted, and yet very little shock has resulted. In moments of great excitement severe injuries may give rise to no pain and to no shock. In the excitement of a cavalry charge an arm has been carried away by a cannon ball and yet no pain has been felt and no shock has followed. This absence of shock, or at least of apparent shock, is also very noticeable amongst the insane.

Cancer

In few parts of surgery has more progress been made than in the treatment of cancer. We have no certain knowledge of the causes of this disease, though it is becoming more and more clear that heredity has

very little to do with the occurrence of cancer; this is directly opposed to the opinion formerly held, when it was thought that cancer occurred in certain families. Until recently operations on cancer gave not very favourable results, for in nearly all cases the disease returned sooner or later. At the present time surgeons have fully recognised two things in connection with cancer. The first is that the operation has to be more thorough than was thought sufficient before, and the second is that the operation must be done at an early stage of the disease. At one time it was thought that cancer was a general disease of the body, though it manifested itself only at one or two spots; but now it is known with certainty that cancer is at first entirely a local disease and that if this local disease be removed completely it will not return, but that if it is left too long it may affect many parts of the body. The conclusion to be drawn from this fact is that any operation for its removal must be thorough, and it must also be performed early while the disease is still confined to its original site. In cancer, therefore, early and thorough operation can give a very great probability of complete and permanent recovery from the disease.

The vital importance of early operation in any such condition must be borne in mind, and time should not be wasted in trying other methods of getting rid of the disease, for they can only lead to a postponement of the best treatment.

At present we do not know of any medicine capable of removing a cancer from the body, but it is not improbable that in time such a medicine may be discovered. It is not that we do not have substances put forward as cures for cancer. Probably every year

one "cancer cure" at least is brought forward. Its value is attested by many cures, but experience shows its lack of value. Unfortunately hitherto all "cancer cures" have failed. New remedies suggested for the cure of cancer always receive trial, and it is only after trial that they are condemned. Violet leaves, thyroid extract, and many other remedies have been brought forward within recent years, but all alike have come to nothing.

Some very superficial forms of cancer, such as "rodent ulcer," have been successfully treated by means of X-rays and by radium, but these superficial forms must not be confused with the deeper and more severe forms of the disease, and for these latter forms there is at present no satisfactory treatment but operation. When, however, a case of malignant disease has become so extensive that the surgeon does not feel justified in operating, then it is clearly justifiable to employ almost any form of treatment which has been recommended, provided that it does not give rise to unnecessary pain.

The Surgery of the Brain

Until a few years ago operations on the skull were confined to trephining or "trepanning," that is, cutting a hole through the skull; this indeed was a very ancient operation, for we find that it was performed even in the neolithic age, and it is certain that some of the patients survived then, for the wound in the bone shows signs of healing. Until the coming of the antiseptic method, however, the operation of trephining involved much risk to life; now, in itself, it may be said to be practically free from danger.

The advances of our knowledge of the physiology of the brain have resulted in enabling the physician to determine often within very narrow limits the situation of tumours in the brain ; and in cases where these localising signs have been clear, surgeons have found it possible to remove the tumours with success. It is clear that such an operation must be attended with great risks, but the seriousness of a tumour in such a situation justifies great risks being undertaken.

In a few cases by means of the X-rays it has been possible to determine the situation within the skull of a bullet, and its removal has been carried out with striking success. That such an operation should have been possible is entirely owing to the introduction of the X-rays. Abscess of the brain occasionally follows long-standing suppuration of the ear, and yet, on many occasions it has been possible for the abscess to be found, to be opened and be drained, and the operation to be followed by complete recovery. As prevention is always more important than cure, it may here be mentioned that most of these abscesses would have been prevented by a timely operation on the ear.

The Surgery of the Heart

Probably the most striking of all the advances of modern surgery is to be found in the surgery of the heart. The time has not long gone by when it was thought that any wound of the heart must inevitably prove immediately fatal, but cases are on record in which a wound of the heart has occurred and yet death has not followed for many minutes or even for several hours. One case is re-

corded in which a man received a bullet in the neighbourhood of the heart and he recovered, and when he died some years later the bullet was found embedded in the substance of the heart. It was not, however, until 1896 that the first attempt was made to operate for the treatment of heart wounds.

A typical history reads as follows :—A man aged 23 was stabbed in the chest by a dagger and as a result he lost much blood and became almost unconscious. The surgeon, by means of an incision, laid bare the heart, exposing the wound in it, and then he carefully inserted some stitches through the walls of the heart so as to close the opening. The superficial wound was then closed and the patient made a good recovery. Every year has added to the number of cases in which operations such as this have been performed, till up to the present some two hundred cases of operations on the heart for stabs and bullet wounds have been published and of these nearly fifty per cent. have recovered. It is obvious that in cases such as these the mortality must be very heavy. It is certain that if nothing had been done almost every single case would have died, but, thanks to modern surgery, it has been possible to snatch from death nearly half the cases.

At first surgeons felt a very natural hesitation in placing stitches in the heart substance, for they feared that they might interfere with the working of the heart, but experience has shown that the heart is much more tolerant than was thought.

Whether it will ever be possible to do more in the way of operation on the heart than the stitching up of wounds of its walls, time alone can show ; with our present knowledge and our present experience it

seems almost impossible that more can be done than has been done; but it would be unwise to declare that, in this matter, the future can have no surprises for us.

The Surgery of the Abdomen

The advantages of the antiseptic method in surgery have been nowhere more clearly seen than in surgery of the stomach, the bowel, and the other abdominal organs. Before Lister's epoch-making discovery the surgeon had the greatest hesitation in opening the abdomen, and in this attitude he was fully justified, for the results of the few operations undertaken were not such as to encourage him to venture to do much more. To-day the situation has completely changed, for when due precautions are taken the surgeon has no hesitation in operating on the organs of the abdominal cavity, and the results are eminently satisfactory.

Probably the operation on the abdomen which is most frequently performed is for the removal of the "appendix." The vermiform appendix is a small hollow projection from the commencement of the large bowel, and it is called vermiform because it resembles, somewhat, an earthworm; so far as we know it has *no function*, and we look upon it as only a relic of a part of the digestive apparatus which has ceased to have any use. It may indeed be mentioned that there are some who think that in all probability it serves some useful purpose. Appendicitis or inflammation of the appendix is a very common disease, and there is reason for thinking that it has much increased in frequency during the last thirty years; though there is clear evidence that it certainly existed

many years ago. We have very little certain knowledge of the cause of appendicitis, but the popular idea that it is caused by the entrance into the appendix of a small portion of indigestible food such as an orange pip, is true of only a very small percentage of the cases. All that can be said with certainty is that it is, somehow, associated with the presence of micro-organisms.

Since appendicitis has been fully recognised, its surgical treatment has advanced greatly, so that at present it may be said that if treated sufficiently early the results are very excellent. Even yet the need for early treatment is not fully known, so that many patients seek treatment after the time when the operation would be most safely performed has passed by, and as a result the risk is greater.

Skin-Grafting

It has long been known that it is possible to a certain extent to transfer tissues from one animal to another, and nearly forty years ago Reverdin first commenced to employ skin-grafting.

When a large ulcer is slow in healing its cicatrisation may sometimes be hastened by skin-grafting. In the earliest form little snippets of skin were taken either from the patient himself or from others and were placed as little islets on the surface of the sore, and, when suitably cared for, from these islets proceeded streams of skin which gradually covered over the whole ulcer.

A marked advance on this was effected when Thiersch introduced his form of skin-grafting. In this method very thin slices of skin are taken by

means of a razor from other parts of the patient or from some one else, and these strips are placed side by side until the whole surface of the ulcer is covered. The slices of skin are extremely thin and include only a small part of the thickness of the skin. This is a much more rapid method than that which preceded it, and it is frequently employed at the present time.

It is not essential that the transplanted skin should be derived from a human being; a portion of the epidermis of one of the lower animals has been successfully transplanted on the human body. When the skin of a negro is employed for the skin-grafting of a white man, a very curious change occurs. For a time the patch of new skin is quite black, but later it gradually loses its pigment and the new skin is of the same colour as the rest of the body. Similarly, when portions of white skin are used to replace vacant patches of skin on the body of a negro, the patch of new white skin will take on the hue of the surrounding epidermis, and in time will become indistinguishable in colour.

Replacement and Transplantation of Organs

The nose is often lost, generally as the result of disease, but sometimes the loss is due to injury, and many years have elapsed since the first attempt was made to replace it.

As Sir Charles Bell has said, the nose "is the organ which chiefly distinguishes the face of man from that of brutes, and the loss of a nose has much more effect on the general appearance than has the loss of an eye." Therefore the importance of the operation is not small. In some parts of India cutting off the

nose is not an unusual method of manifesting revenge, and this is the reason that operations for replacing a lost nose have been practised for many years there.

In Europe the operation for replacing a lost nose was first attempted in Italy. The method employed was different from that used in India, so that there are two main operations for this deformity—one which is known as the Indian operation, and the other is commonly called the Taliacotian method, after Tagli-cozzi who devised it.

In the Indian method a pear-shaped flap of skin is raised from the forehead and turned down so as to occupy the place of the nose, where it is made fast with stitches, and there it becomes adherent after a few days. In the Italian method the flap of skin is taken from the arm of the patient, the arm being fixed by an apparatus in such a position that it is possible to attach the flap of skin to the site of the nose while it is still fastened to the arm by a bridge of skin. Later this connection is severed. A fair measure of success has attended these operations if suitable cases are chosen, though the result never equals in appearance the original nose of the possessors.

In the chapter on Organotherapy an account has been given of a diseased condition called myxœdema, which results from atrophy of the thyroid gland, and it is there also mentioned that a similar condition follows complete removal of that gland. Treatment by administering an extract from the thyroid gland of the sheep gives very good results, but it has been suggested that it would be better if the patient could be given a new thyroid gland in place of the one lost. Transplantations of the thyroid gland of the

sheep have been made into the tissue underneath the skin of the patient, and when care has been exercised the wounds heal satisfactorily, but, so far as I know, in no case has the transplanted gland shown any indication of functional activity, for more or less rapidly it undergoes atrophy.

Attempts have also been made to employ, not the thyroid gland of a sheep, but portions of the human thyroid which have been removed from another patient in whom the thyroid gland had undergone overgrowth, but here also the evidence in favour of the transplanted organ being of functional utility is very small. There can be no doubt that transplanted glands like this as a rule atrophy, and this is probably because the blood-vessels of the gland do not get sufficiently connected with the blood-vessels of the persons to whom they have been transferred to enable the glands to survive, so that the blood supply of the transplanted gland is insufficient. The principle of the treatment is no doubt perfectly correct, but at present the practical details are probably responsible for the result. There can be little hesitation in saying that in the future the method will be improved and will be successful. When this method of transplantation of organs is successful, it is possible that some other organs, especially those provided with internal secretions, may be transplanted also.

Paraffin Injections in the Treatment of a Misshapen Nose

Within recent years attempts have been made to remedy the shapes of noses, especially those which are too hollow on the upper surface (saddle-back

noses, as they are often called), by injecting solid paraffin underneath the skin. A nose of this shape may be the result of injury or disease, or it may be the natural shape. If the skin is fairly loose over the depression the case will be suitable for the operation, which consists in the injection of solid paraffin under the skin into the hollow of the nose. Usually the paraffin is melted so that it is only just liquid as it enters the tissues, but some operators prefer to use paraffin in a solid condition, as it is safer. The greatest care has to be taken in ensuring that the paraffin is free from germs and that it is at the right temperature. Also care must be taken that too much of the paraffin is not injected. It is better, on the whole, to inject too little rather than too much, for, if necessary, a little more can easily be added. The process generally does not require an anæsthetic for the pain is not great, but if required an anæsthetic can be administered. When the operation is performed only in suitable cases the results are good and the improvement in the appearance may be very marked. There are also cases in which an excessive prominence of the nose can be removed, but the cases should be carefully selected before being submitted to operation, for it is much easier to do harm than good.

Wiring Broken Bones

When a bone is broken it is usually not difficult to "set it," that is to say, to place the fragments in the position in which they were before the bone was broken, and when this has been done and no muscle or other tissue is between the ends of the fragments, then the bone will unite readily and at the end of

four or five weeks it will be possible to use the limb again. This is what may be called the usual or natural course of the healing of a broken bone, but it may happen that it is found to be impossible to get the two fragments in position; and the X-rays may show that there is some displacement still. In cases such as these it is often advisable to operate in order to place the two fragments into the right position and to keep them there. The surgeon makes an incision down to the bone, removes any tissue which is interfering with the fragments coming together, and then by one means or another fixes the two fragments so that they cannot move. The older method was to use silver wire which was passed through holes in the bone, first through one bone and then through the other, and then the ends were twisted together till the wire became fairly tight; then the excess of wire was cut off and the wound was closed. The wiring of bones is in many cases very satisfactory, but it does not always succeed in holding the two fragments firmly together. Other methods have been devised to take the place of wiring. In one a hole is bored through both bones and a screw made of steel and covered with silver is put into the hole, and if the size has been carefully chosen and the hole has been correctly placed the two fragments will be held very firmly in position.

A still further advance is the use of metal bars or plates, which are screwed to both bones and which hold them firmly together. These plates may be of silvered steel or they may be of aluminium. The most essential point in the operation is that it should be thoroughly aseptic, for even a very little sepsis may materially interfere with the success. Opinions

A Broken Knee-cap, soon after the injury

This is a skiagram (X-ray photograph) of a broken knee-cap (patella); on the left are seen the two fragments widely separated. If treated without operation this injury usually leads to permanent lameness.

A Broken Knee-cap United by Silver Wire

This is a skiagram of the same knee, showing the effect of "wiring" the broken knee-cap. The two fragments of the bone have been brought together, a piece of silver wire has been passed through them, and the ends of the wire have been twisted together. The wire is shown by the black line passing through the fragments.

differ at present as to the frequency with which this operation for the treatment of simple fractures is required, except in the case of one bone, and that is the patella or knee-cap. When the patella breaks across, the strong muscle of the thigh, which is attached to the upper fragment, pulls the two pieces far apart, and it is extremely difficult by means of splints and bandages to bring the two fragments together and to hold them there. Therefore, unless the age of the patient or his health contra-indicates an operation, it is advisable to operate on fracture of the patella. Many methods have been devised, and they all have for their object the bringing the two fragments together and holding them in apposition, wires being made to pass from one fragment to the other. When care is taken to avoid sepsis the results are all that can be desired, for the two fragments unite by bone tissue and the bone is as strong as it was before.

Sometimes when a simple fracture of a bone has been put up in the ordinary way and has been allowed to remain in splints for five or six weeks and then is taken down, it may happen that, to the surgeon's disappointment, it is found that the bones have not united, and that even keeping the limb in splints for another month or two will not result in the healing of the bone. This condition is called "ununited fracture," and until the introduction of the antiseptic method it frequently gave a great deal of trouble to surgeons. Various methods were adopted to induce the two fragments to join, but rarely did they prove successful. In cases such as these all surgeons are agreed that an operation must be performed. The details will necessarily vary according to the special

method employed, but the general principles will be the same. An incision is made so as to expose the site of the fracture; a small portion of each fragment will be removed so as to freshen the surface, and then by means of wires, or by screws or by plates, the two pieces of the bone will be fixed together. Here also the very strictest attention to asepsis is essential if successful results are to be obtained.

CHAPTER XVII

THE VALUE OF DRUGS

At the present day the opinions which exist even amongst medical men as to the value of drugs differ greatly from one another. While some consider that drugs are of the greatest importance in the treatment of disease, others look upon them as almost valueless, and it is certain that the recent great advances in surgery have done much to assist in the neglect of the use of drugs in medicine. For it has been found possible by surgical operation to cure many conditions which at one time could only be treated by means of medicine, and even then the results were often unsatisfactory.

There was a time when the belief in the efficacy of drugs was very great indeed. It was thought possible to cure any and every disease by suitable medicines or applications. Any one who reads the older works on materia medica, as the study of drugs is called, will be much surprised at the claims made on behalf of many of the substances dealt with. No condition was considered to be irremediable, but each and every disease had its appropriate remedy.

It will be clear to any careful reader of old works on drugs that many of the claims made for substances now almost forgotten must be utterly ill-founded; otherwise it is intensely unlikely that the drugs would now be neglected. We have records of

the exact treatment given to many persons in the eighteenth and in the early part of the nineteenth century, and it is surprising to medical men of the present day that so much treatment by medicines was considered necessary. At that time it was hardly recognised that there is a *vis medicatrix naturæ*, or a healing power of nature, and that the body is capable of curing itself to a very great extent, just as a lifeboat has the power of righting itself even when it has been overturned.

There is, of course, a limit to the self-healing powers of the human body, and sometimes its well-meaning attempts at cure serve but to aggravate the disease. Even after allowance has been made for exaggeration in the claims in favour of the value of drugs and for the natural healing powers of the body, it would be rash to assert that our predecessors were utterly wrong in all their ideas of treatment, that every claim for every drug was founded on fiction and not on fact. There is a solid foundation for the employment of drugs in medicine, and it is probable that at the present time they are unduly neglected. In the use of drugs, however, there is an error into which those treating disease are liable to fall. The symptoms are mistaken for the disease, and the physician in the past was, we cannot help thinking, a little too prone to be satisfied with treating the symptoms. The symptoms are merely the outward expression of the within-lying disease. When a person has scarlet fever the disease really consists in an invasion of the body by the microbe of scarlet fever, and the symptoms—the raised temperature, the redness of the skin, the pain, and the soreness of the throat—are merely the results of the invasion of the

body by the microbe, the outward expression of the disease. In treating a malady the aim should always be to deal, when such is possible, with the essential cause, and the symptoms should be treated only in so far as they are causing the patient unnecessary or excessive pain or discomfort.

When a patient has bronchitis one of the most striking symptoms is cough. This symptom may be extremely trying to the patient, but it arises really from an effort of the body to remove the cause. It is the accumulation of mucus in the air tubes that is making the patient cough, and the cough is intended to remove this mucus from the lungs. If, therefore, treatment is given merely to suppress the cough, it may do harm, for it may interfere with the natural attempt to remove the morbid secretion from the lung, and this is why patent medicines for a cough taken without medical advice so often prove highly injurious. They may indeed stop the cough, but they may, by stopping the cough, allow the mucus to accumulate in the lungs and thus make the disease greatly worse, or they may even lead to a fatal issue. Sometimes, indeed, it may be desirable to treat symptoms, and we may take the same illustration as before. In certain cases it may well happen that the violence of the cough may be in excess of what is really required, and as a result the patient is unnecessarily troubled. In a case like this a sedative to allay the cough or diminish its violence may be perfectly reasonable, but it needs knowledge and skill to appreciate the states in which the sedative should be given and those in which it must be carefully withheld.

Again, a symptom such as pain may be doing

absolute harm by interfering with sleep, and the loss of sleep may risk the patient's life. Even in the treatment of pain, however, the greatest care must be used in giving sedatives, for it frequently happens that pain is an indication of serious disease, and if the pain be obscured by the indiscriminate use of sedatives, the diagnosis may be rendered difficult and the progress of the disease obscured. We may take as an example of this the pain of appendicitis. Here the pain is an indication of severe affection of the appendix, and in all probability it will require an operation sooner or later. If this pain be drowned by sedatives, one of the most valuable indications of the progress of the disease will be lost, and should a surgeon be called in for the purpose of diagnosing the disease and deciding on the desirability of an operation, his task of diagnosis will be immensely increased. In these and many similar cases the treatment of the symptom is much less important than the treatment of the cause, for usually if the cause be removed the symptom disappears almost immediately. When, however, as not very rarely happens, the cause is undiscoverable, the treatment must consist largely in the management of the symptoms, but always regard must be paid to the need for not interfering unnecessarily with symptoms which may have a beneficial action.

As to the value of certain drugs there can be no question. To give an example known to every one, I may quote quinine. The value of quinine in malaria rests on so sure a foundation that no one will venture to dispute it. I will give an early instance. In 1845 the British Government sent an expedition up the Niger. It was partly scientific in nature, but it was

also intended to assist in the formation of trading colonies up the river. A large number of the members of the expedition died of malaria, and many more were attacked severely by the disease, so that the formation of the trading stations became practically impossible. In this expedition no special precautions were taken to prevent the occurrence of malaria amongst the crew, and the result was as I have mentioned.

In 1854 another expedition was sent up the same river by the British Government, but it was arranged that the surgeons of the expedition should administer quinine every day to all its members, with the result that no deaths occurred and that the expedition returned having had a very small amount of sickness on board.

We now know how quinine acts. It exerts an antiseptic action on the germ causing malaria, the *Plasmodium malariæ*, and if taken to prevent malaria it can act as soon as the germ enters the blood; but the fact of the value of quinine was known long before we understood its mode of action. A certain number of other examples might be cited, but it must be acknowledged that the cases in which a drug acts as promptly and as certainly as quinine does in malaria are few. Nevertheless, though the degree of certainty is slighter, many instances might be quoted where a drug has a definite invariable action on a certain organ, structure, or tissue, and the physician may rely with confidence on the drug when he needs it. Some of the uncertainty which exists as to the value of a drug may reasonably depend on the difficulty of obtaining it in a state of purity, for many substances are habitually adulterated. One bark is replaced by another, or one leaf is supplied in place

of another closely resembling it. Most of these substitutions are for the sake of extra gain, but on the genuineness of a drug may depend the health or the life of many patients. It is therefore the duty of the State to see that drugs are genuine and pure.

Patent Medicines

One of the most wonderful facts in connection with medicine is the great faith which so many people have in secret remedies, or as they are called in this country, "patent medicines," because they bear a Government stamp. Many a man, who has little belief in the knowledge or skill of doctors, will pin his faith to some patent pill or powder. He will doubt the ability of a doctor who for years has studied medicine and surgery, and who has the opportunity of examining him so as to diagnose the disease, and he will put his trust in a patent medicine, making his own diagnosis and choosing his own treatment. I would not for one moment deny that many secret medicines have proved useful; it would be strange if they had not, for they contain only the ordinary drugs which are used in prescriptions.

The real charm lies in the fact that the composition of the patent medicine is unknown, and therefore it is thought that it may contain some rare and unknown drug, possessing marvellous properties. If every patent medicine were required to bear its formula on the bottle or box containing it, most patent medicines would lose nine-tenths of their reputation. It is interesting to note how much the advertisements of secret remedies resemble each other. Often they run on lines such as these :—

The rare plant has been found in the pathless

forests of Brazil, and the half-dying traveller as he sinks to the ground almost unconsciously picks and eats some brilliant flower or shining leaf: he cares not if it should prove poisonous, for he feels that his strength is spent and that he must die. Yet within a few seconds his heart is beating with greater force; his eyes, dim with the approach of death, are become once more clear; his mind, wandering with the delirium of fever, returns to him; his tired limbs receive an immediate accession of strength, and he feels, nay more, he knows, that he is saved. With feeble hands he hurriedly gathers more of the brilliant flowers, or of the shining leaves, as the case may be. He carries them to his mouth and he eats them ravenously, and then he slowly sinks into a long dreamless slumber. Hour after hour he sleeps on, and at length he awakes and he is well. His mind is clear; all his aches and pains are gone; and as he rises to pursue his journey, in thankfulness for his recovery he raises his hand to heaven and registers a vow that when he reaches civilisation he will return with help and will gather loads of the precious flowers (or leaves), and he will take no rest till he has made known to suffering humanity the precious balm that he has discovered. And, in conclusion, he informs all and sundry that he has determined to devote the remainder of his days to spreading abroad the glad tidings and to purveying to the said suffering humanity the healing drug at almost cost price, which proves to be three shillings and ninepence for a four-ounce bottle, or ten shillings for a big bottle containing four times the quantity in the other.

Sometimes the story varies a little. It may be the traveller aforesaid was not half dying, but was travel-

ling in good health through the pathless forests of Paraguay, when he finds an aged squaw lying on the ground far from her village. In this case it is the aged squaw who is half dying, and the traveller, touched with compassion, offers her food and drink. Refreshed with this timely succour, the aged squaw tells her story. She has been turned out of her village, partly because she is old and useless, and partly because she had been suspected of witchcraft, and partly because she has a knowledge of the virtues of herbs which she may have used sometimes for the detriment of her enemies, and she has been left to live in the forest as best she may or to die of hunger or of wild beasts. The compassionate traveller marvels at the brutality of the villagers, and tends with care the aged squaw until in a few hours or days she dies. But, ere she dies, in feeble accents and with halting breath she imparts to him a great secret. A herb, a specimen of which fortunately grows close by so that she can point to it, possesses marvellous curative properties for all the ills that flesh is heir to; and she tells him all it can do; how it should be prepared and how taken. At the very moment she has finished supplying him with these important particulars, she falls back dead; and this traveller vows that (provided the plant has the virtues ascribed to it) her death shall not have been in vain, for he will spread far and wide the fame of the virtues of the plant, made known to him by the aged squaw. And so he does, and this also is three shillings and ninepence a bottle, or ten shillings for a big bottle containing four times as much as the other.

Sometimes it is not a traveller at all who makes the

great discovery. It is a man who had a great-great-aunt, and this aunt had lived to the age of 110 years, to the wonder and envy of all her friends and relations. This aunt had had a great reputation for administering to the ailments of the poor of her neighbourhood, and she always gave them twenty drops of a bright brown liquid which she prepared herself. It did not seem to matter much what was wrong with any of the poor, they always had the twenty drops of the bright brown liquid—whether it was mumps or measles, paralysis or spasms—and the result was always wonderful. To show her *bona fides* the old lady often took some of the drops herself, and it was the popular idea that it was to these very drops she owed her great age and good health. As she lay a-dying—for she did die, though I cannot say why—she tried to speak to her great-great-nephew, but in vain ; and she could only point with a shaking hand across the room. After her death her nephew tries to imagine what her meaning was when she pointed, and at last he decides that she wished to point to an old, old, oak bureau. This he searches for some hidden treasure, but he searches in vain. Again and again he returns to the fruitless quest, and he is about to give it up in despair when his foot catches in the leg of the old, old, oak bureau, and over it falls. The fall is too much for it—it bursts to pieces, and a hidden drawer is revealed. With frantic haste he opens the drawer, hoping to find many guineas or bank notes, but no ; in it is only a single sheet of paper. He seizes it, and scans it with an anxious eye. The ink is faded and the writing is in an antique hand, but he sees enough to know that here he has the recipe for the bright brown liquid ; and though

naturally somewhat disappointed at first, he finds in time that his aunt has left him what is of more value than money—a remedy to cure all maladies, from mumps to measles, as mentioned already. By its aid he can alleviate the woes of the human race, and in order that there should be no mistake about the purity of the drugs, he does not publish his aunt's recipe, but he has it prepared at what is practically cost price, and he offers it to suffering humanity at three shillings and ninepence per bottle, and a reduction on taking a quantity.

Patent medicine vendors would not publish such tales as these (except, of course, when the tales happen to be true) unless they thought that the strange manner in which they had obtained the secret of the medicine would recommend it to the public. It is the wonderful way in which the secret has been learned that makes its value. This reasoning may be a little illogical, but those who put their trust in patent medicines seldom care much for logic.

What is the remedy? The simplest and fairest method, in my opinion, is not to forbid by law the sale of patent medicines, but to make it compulsory that every patent medicine should bear on its bottle or box a correct statement of its constituents. Then every purchaser would know what he was buying, and he would not be deluded by the charm of the unknown.

There is another evil almost as great as that of patent medicines. It is the practice of self-drugging. Many men and women consume large quantities of antipyrin and of phenacetin and of many other similar drugs. They buy them in the tablet form, and take one or more tablets whenever they feel so inclined. Immense harm is done by this practice, for the persistent and

indiscriminate use of these drugs affects injuriously many tissues of the body and renders those who indulge in them peevish and restless and incapable of sustained effort. Unfortunately the practice appears to be spreading, perhaps because the facilities for it are increasing. Probably the most harmful form of self-medication is the custom of taking narcotics. Opium, morphia, chloral, and cocaine are the chief drugs of this class which are taken. Unfortunately, only too many commence to take these poisons without understanding that once the practice has been begun it degenerates rapidly into a habit, from which it is almost impossible to escape by any effort of the will. By the aid of others the attempt to relinquish the taking of morphia or one of the other drugs mentioned above may prove successful, but it is only with great difficulty. Before any one commences the practice of taking any narcotic, whether it be for pain or sleeplessness, he should realise that he is about to become a slave, and that release from this servitude is unlikely.

CHAPTER XVIII

ORGANOTHERAPY

FROM a very early time there has been a tendency to ascribe certain virtues to certain organs of the body, and the existence of such a belief is not confined to primitive races, but it can be seen even in highly civilised peoples of the past and of the present day. It follows almost naturally as a corollary to such a belief that the administration of a preparation of any organ might be expected to be beneficial in a case where the special quality supposed to exist in it was lacking. As bravery was believed to be connected with the heart, savage warriors imagined that to eat the hearts of their enemies would increase their own courage. From a custom such as this it was an easy step to imagine that the administration of the liver, for instance, of an animal might be of use in disease of the liver in man. We find in the works of Celsus and Dioscorides recommendations for the employment of various organs derived from animals for the treatment of disease of those organs in man. The lung of the fox was advised for shortness of breath, for the fox is able to run long distances at a high speed ; the brain of the hare for tremors, and rennet for disorders of the stomach. Many of these and similar remedies continued in use until comparatively recently, but about the beginning of the nineteenth

century they were almost all discarded from the pharmacopœias, and we find hardly any example of their employment until, about 1840, in consequence of advances in our knowledge of the physiology of the stomach, an artificial gastric juice containing pepsin was prepared from the stomach of the pig for use in dyspepsia; and if suitably prepared and suitably administered, it does prove useful in certain forms of this disease.

Similar preparations have been prepared from the other great digestive organ, the pancreas, and pancreatic juice is widely used for some forms of indigestion, but even more for the predigesting of food. By this is meant the subjecting of some food to the action of an artificial pancreatic juice (generally prepared from the pancreas of the pig); then the food is taken, and as it has already undergone partial digestion, the digestive organs of the patient are not so severely taxed. Usually milk is the food treated in this way; to a certain quantity of milk some artificial pancreatic juice is added, and the mixture is kept at the temperature of the human body for a certain time, with the result that the ferments of the pancreatic juice act upon the constituents of the milk in very much the same way as the ferments of the human pancreatic juice would have acted if the milk had been swallowed. The method is certainly of value, but it has its limitations, and usually it is found better not to allow the predigestion to proceed very far, otherwise the product may prove too unpalatable to be taken readily.

The theory of the use of pepsin and of pancreatic juice is very simple, but now we have to consider a more complex example of the treatment of disease by

the administration of organs, or organotherapy as it is called.

The secretions of the glands of the body are for the most part poured out into the cavities of the body, there to serve some useful purpose, as, for instance, the saliva is poured out into the mouth to assist in the digestion of the food.

For many years, however, we have had reason for thinking that several glandular organs of the body secrete substances which are not poured out by ducts, but are absorbed by the blood-vessels and so pass straight into the circulation, and thus are able to perform the functions for which they are intended. These are called "internal secretions," and modern physiology attaches great importance to them. Recently it has been recognised that certain affections of the body may be caused by absence or disease of some of these organs, and the first organ which was conclusively shown to have an internal secretion was a gland in the neck which is called the thyroid gland.

Every one knows that in several countries, especially Switzerland and Norway, there are certain districts in which a large proportion of the inhabitants are affected with a prominent swelling of the throat called "Goitre." This condition occurs also but to a much less extent in England; and as it is especially common in Derbyshire, it is frequently called the "Derbyshire neck." The disease is very old, for it was well known to the Romans and it is mentioned by Juvenal. It is due to an enlargement of a gland which is situated in the front of the throat immediately in front of and to the side of the air-tube.

It is called the thyroid gland, and until recently nothing was known of its function. At last, in 1883,

it was noticed by Reverdin that some patients from whom the whole of the enlarged goitrous thyroid gland had been removed suffered from a group of curious symptoms which were evidently connected with the removal of the gland. The symptoms are these : the patient experiences at first a feeling of lassitude, and this tends gradually to increase till even the slightest exertion is wearisome; active exercise and work are given up, and the existence of the patient is almost entirely sedentary. A feeling of coldness tends to develop, and later on the temperature may be a degree or two below the normal. The tissues beneath the skin gradually become distended by a gelatinous liquid, so that the features become much more rounded and the appearance of the face is greatly altered. Perspiration is diminished, with the effect that the skin becomes very dry. The mental processes become slowed, and the mind is sluggish both in understanding facts and in acting on them. It was soon seen that these symptoms were identical with those which had recently been described by Ord and named myxœdema, and it was known that in myxœdema the thyroid gland was extremely shrunken and atrophied, and therefore it was clear that somehow the removal or atrophy of the thyroid gland caused the appearance of these symptoms. It was thought by some that the symptoms might be due to some interference with the nervous system during the operation for the removal of the thyroid gland, but evidently this could not be the correct explanation, for the symptoms were in great part removed when an extract made from the thyroid gland of a sheep was injected under the skin of these patients.

It is clear, then, from these and many other ob-

servations that the thyroid gland secretes a substance which is carried away by the blood-vessels and has a very important effect on the general mental and physical well-being. Evidently the thyroid has an "internal secretion." It was known that in many places, both in goitrous countries and also in countries where goitre is extremely rare, that children are occasionally born who develop exceedingly slowly. These are called "cretins." The name "cretin" is applied to two conditions which are really different. In one the lack of development is accompanied by an enlarged thyroid gland; in the other the thyroid gland is absent. To the members of this latter class the name of "sporadic cretin" is given, because the condition may occur in districts which are not goitrous.

The "cretin" of a family may at the age of twenty only equal in height one of his brothers a dozen or sixteen years younger; and his mental development is retarded to an equal extent, for he will be unable to read, and indeed he may have no knowledge of the alphabet, and speech may be badly developed. The features are rounded and coarse, and in fact the patient is a representative on a small scale of a person suffering from myxœdema. In these cretinous children the thyroid gland is absent. So we are able to explain this form of cretinism by the congenital absence of the thyroid gland.

If this explanation were correct, it might be possible to effect some improvement in these children by means of administering an extract from the thyroid gland. If the case has not been left too long untreated, it is found that the administration of an extract of the thyroid gland in a suitable dose may

lead to a rapid increase in the rate of growth of the patient, and the mental improvement is generally equally well marked. These beneficial effects are more noticeable the earlier in the life of the patient the thyroid extract is given.

When the idea of administering extract of the thyroid gland in myxœdema first arose, it was thought necessary to inject it under the skin, but later it was suggested that the same result could be obtained more simply by giving the extract of the thyroid gland, or even the thyroid gland itself, by the mouth. Indeed in an early stage of evolution the thyroid gland had a duct by which the secretion was poured into the throat, and a knowledge of this fact might have suggested earlier that giving the thyroid gland by the mouth might be quite as efficacious as injecting it under the skin. At present thyroid extract is always given by the mouth, and it has proved of great value in myxœdema.

It may be taken therefore as proved, that the thyroid gland secretes a substance which is absorbed into the blood-vessels and so is carried all over the body, and that this substance is of so great importance to the animal economy that its absence is followed either by lack of development or by a marked degradation of the vital processes both of the body and mind.

The thyroid gland was the first known example of an organ forming an internal secretion; and even up to the present time it has remained the most striking instance of this.

The extract of the thyroid gland has also been used for other diseases. Thus, in certain maladies of the skin it seems to have a very definite effect, and

in several other conditions the extract of the thyroid gland has proved to be of service.

Another instance of an internal secretion is afforded by the suprarenal gland. This is a small body situated at the upper end of each kidney though not connected with it. Even now, after much investigation, we know but little of the action of this gland, but we do know that when the gland is diseased, and especially when the disease is far advanced, so that hardly any healthy tissue remains, a curious condition of the body occurs, in which the patient becomes very weak; he is troubled with vomiting and anæmia, and he shows also a still more striking sign, for the skin becomes of a curious coppery tint. This disease is known as "Addison's disease," and though we cannot account for the symptoms we feel quite sure that there is an association between the atrophy of the suprarenal gland and these troublesome symptoms, and the evidence which we possess goes to show that the gland acts, not through the nervous system as was at first suggested, but through the formation of an internal secretion.

That an extract of the suprarenal gland has a powerful action on the body there can be no doubt. It causes strong contraction of all the smaller blood-vessels, and thus it is of much use in preventing bleeding from the smallest blood-vessels, and the extract has also proved of value in cases where the blood pressure is very low, for it can raise the blood pressure by contracting the peripheral vessels. It is worthy of note that if extracts prepared from the suprarenal gland be administered in too large a dose or for too long a time serious symptoms may result.

Other organs, such as the liver and the pancreas, also probably possess internal secretions in addition to the external secretion of the bile and the pancreatic juice, and there is some evidence that extracts made from these glands are of value in some diseases of those organs.

The subject is new, but it is not improbable that in the near future we shall possess sufficient knowledge of the internal secretions of the various organs to enable us to utilise them in the treatment of disease; but I have said enough to show that, in some cases at least, there is a solid basis, both theoretical and practical, for the employment of organs or extracts made from them in the treatment of disease.

CHAPTER XIX

MALARIA

MALARIA is a convenient generic name for a number of diseases, characterised by a curious sequence of events; an attack begins with a shivering fit, or "rigor" as it is termed, and this is followed by a "hot stage" with a high temperature, and then comes the "sweating stage," with profuse perspiration, and a return of the temperature to the normal. A similar attack recurs at regular intervals, sometimes every day, sometimes there is an interval of a day or even of two days, and to these varieties the names of quotidian, tertian, and quartan are given. Ague is one of the milder forms of malaria, and like all the less severe varieties of the disease it has a distinct interval with absence of fever between two attacks; these are called intermittent fevers. When the temperature falls after an attack but not to the normal, the fever is described as "remittent."

Malaria has been known from a very early period of the history of the world, and in most countries it has been seen at one time or another. Of its importance there can be no question, for in many regions of the globe almost two-thirds of the total mortality is caused directly or indirectly by malarial fevers and their allied disorders. Dr. Cornish of Madras has said that "Fevers in one form or another destroy twice as many people in India as small-pox, cholera, and all other epidemic causes put together." The

cause and control of malaria and the other diseases allied to it are therefore of great moment to all concerned with the welfare of the countries where these maladies are rife.

Until some twenty years ago the true cause and mode of spread of malaria were utterly unknown, and it was looked upon as the direct result of certain climatic conditions. The typical requirements for the production of malaria were considered to be heat, moisture, and the decomposition of vegetable matter. In low, wet, and warm localities much malaria is generally found, and that a marsh was looked upon as furnishing the essentials for the production of malaria is attested by some of the names given to the disease: it was often spoken of as "paludal fever," and the unknown poison which produced it was called "marsh miasm." It was recognised that a lake did not give rise to the disease, and even a marsh when well flooded with water did not appear to be prone to cause malaria, but the condition most favourable was a marshy district which was half dried lying under a tropical sun. That such a circumstance would favour malaria was well shown in the district of Burdwan in Bengal. The soil was dry and it had been a healthy district, until gradually the drainage of the country was interfered with by the silting up of the natural and artificial outlets for the water, so that the soil became water-logged; and then it was not long before malaria became very prevalent and the death-rate rose greatly.

Such are the conditions which appear to be specially favourable to the production of malaria, but they are certainly not essentials. In 1794 the summer was very hot and dry, and the British army which

was acting in Holland against the forces of the French Republic had suffered but little from disease. In August it encamped at Rosendaal and Oosterhout, where there was a sandy plain with a perfectly dry surface, supporting no vegetation except some stunted heaths. However, a few inches below the surface there was water, but it was clear and apparently fit for drinking. In this soil, where no decomposing vegetable matter existed, malarial fever soon showed itself, and prevailed to a great extent.

In the year 1809 several regiments of the British army in Spain encamped in a hilly ravine down which had flowed a stream. This, however, had ceased to flow, but here and there among the rocks still remained pools of water, so pure that the soldiers were anxious to camp near them, but before the next morning several men were seized with malarial fever.

Dr. William Ferguson, who recorded the incident, says: "Till then it had always been believed amongst us that vegetable putrefaction (the humid decay of vegetables) was essential to the production of pestiferous miasmata; but in the instance of the half-dried ravine before us, from the stony bed of which (as soil never could lie for the torrents) the very existence even of vegetation was impossible, it proved as pestiferous as the bed of a fen."

After the battle of Talavera, when Wellington defeated the French under Victor, the British army was compelled to retreat by the approach of another French army under Soult; it followed the course of the Guadiana river till it reached the plains of Estremadura. The country was extremely dry from want of rain, so that all the streams and even the Guadiana itself had ceased to flow, and they formed

A Non-Malarial Mosquito (Female)
Showing the body parallel to the surface on which the insect rests.

A Non-Malarial Mosquito (Male)
It will be seen that the body is parallel to the surface on which the insect is resting. Compare this with the attitude of the Mosquito of Malaria.

Mosquito (Male) of Malaria
Showing the inclined resting attitude.

only lines of detached pools in the river beds, yet the troops suffered from malaria "of such destructive malignity that the enemy and all Europe believed that the British host was extirpated."

It was clear from these and many other similar histories that vegetable decomposition was not essential to the production of malaria.

Many more facts could be quoted to show that observers more than a century ago had noticed that malaria might occur in conditions very different from those prevalent in tropical marshes. For malaria also occurs in temperate climates, and it was formerly widely prevalent in the British Isles, especially along the eastern coast of England, and at one time it occurred in London. It is endemic in the moors and marshes of Oldenburg, Hanover, and Westphalia in Germany. In Holland, Groningen, Friesland, and Zealand suffer much, and it occurs as far north as the central depression of Sweden, especially on the shores of Lake Wener. Its former prevalence in England is shown by the fact that both James I. and Oliver Cromwell died from ague.

Malaria may, as we have seen, exist under many conditions, and in many parts of the globe, but it has certain limitations. Although it may occur as high as 7000 feet above the level of the sea, it is quite exceptional for it to attack persons raised even a few feet above the level of the ground. In some countries the houses are built upon piles, and those who sleep in them are not liable to be attacked, and the same immunity is secured by the natives of South America by sleeping in the branches of trees. A small extent of open water is sufficient, in most cases, to keep the disease away, so that men on ships, even a quarter of

a mile from a malarious shore, generally escape. A belt of trees or even a high wall has appeared to keep off malaria. In Guiana we are told that the settlers can live fearlessly and unhurt, close to the most pestiferous marshes and to leeward of them, provided that a screen or belt of trees be interposed. However, a wind blowing from a malarious district may carry the disease to spheres previously free from the disease. A much more important limitation concerns the time of day. It is well known that even the most dangerous districts are practically safe while the sun is up, but that danger arises as the sun sets, and so it happens that when the crew of a ship lying off a malarious coast land during the daytime but always return to the ship to sleep, they do not become attacked with the disease, but if they sleep on shore they are generally affected. In 1766 the warship *Phœnix* was returning from the coast of Guinea. The officers and the men were perfectly healthy till the ship touched at the island of St. Thomas. Here nearly the whole crew went on shore, and all of these except sixteen returned to the ship to sleep. Of these sixteen every one was attacked with fever and thirteen of them died. The rest of the crew consisted of 280 men, and they went in parties of twenty or thirty on shore during the daytime and rambled about the island hunting and shooting, but they returned to the ship at night, and not one of them who so returned suffered in the slightest.

Malaria is very liable to appear in tropical countries when forests have been cut down and agriculture has been started, but it tends to disappear later, when the country is thoroughly cultivated.

The value of cinchona bark for the treatment of

malaria in all its forms has been known now for nearly three hundred years. Its practical utility was acknowledged by all, even while the most varied theories existed as to the cause of the disease, and mode of action of the drug. Although we now know the true etiology of malaria, and can do much to prevent the appearance of the disease in districts where it has been endemic hitherto, cinchona bark and its derivative, quinine, provide still the best method of treating malaria in all its forms. There is no well-authenticated record of the use of "Peruvian bark," as it was first called, before the year 1638, when the Countess del Chinchon, the wife of the Viceroy of Peru, was cured of a malarial fever by the use of the bark; and the bark owes its name of cinchona to this fact.

Some have doubted this etymology of the word, denying even the existence of the Countess del Chinchon. The native Peruvian name for the tree is said to be Kina or Kinken, and the name cinchona is said to be derived from this. It is also said that the natives do not value the bark for intermittent fevers, but have a prejudice against it, and that a native has been seen dying with malaria and bearing on his back a load of the bark and yet unwilling to touch it or unaware that it would cure him.

When the use of Peruvian bark was first introduced into Europe, it met with violent opposition even from physicians of high authority. Sydenham, who was the greatest English physician of the seventeenth century, did much to promote its adoption in this country, and gradually it attained to the highest position in the treatment of malaria. Quinine was separated from cinchona in 1820, and has to a very large extent replaced the bark and its preparations.

CHAPTER XX

THE POLITICAL IMPORTANCE OF MALARIA

THE advance or decay of a nation is generally attributed in historical works to such obvious causes as wars or religions, and equally widespread is the idea that by passing laws it is possible to elevate a people. Sometimes we find that progress is ascribed to an individual leader, without whom, we are told, no progress would have been made. I have no wish to belittle the importance of all these influences in assisting or retarding the national advance of a people, for they are, undoubtedly, very important factors in the progress of a nation, and the advent of a leader may suffice to turn the scale one way or the other. There is a very definite popular belief in the efficacy of legislation to determine the welfare of a country; but, though the passing of laws may have an indirect effect in the matter, the direct effect is very much less than is usually imagined.

Races of animals disappear. In the ages of the past innumerable kinds of animals have lived their lives and have lasted for many thousands, perhaps millions of years, and yet, as the records of the rocks tell us, they have come to an end. Within more recent time, indeed, man has been one great cause of the disappearance of species of animals, but we may be quite sure that he has only been one cause, for, ages

before man dwelt on the earth, there occurred the same extinction of various races of animals. May it not well be, therefore, that what holds good for the lower animals may be applicable to man? Now, the destruction of a whole race of animals is always dependent, if we put aside the destruction caused by human agency, on want of food, climatic conditions, or disease. That want of food may cause widespread destruction of animals is known to all, and especially when combined with adverse climatic conditions, the destruction may be enormous. Darwin estimated (chiefly from the reduced number of nests in the spring) that the winter of 1854–55 destroyed four-fifths of the birds in his grounds.

Of this loss of food man, without doubt, is often a cause, and so he is, in this way, indirectly a cause of the disappearance of animals, but he is only one of many causes. That disease may almost destroy a race of animals is not less clear, for we know of many most virulent epidemics amongst animals. If these factors have such effects on animals lower in the scale than human beings, may they not, also, have similar effects on man?

Want of food may benefit a race if it stimulates to greater exertion and eliminates those who are unfit, but where the want of food is persistent and great and cannot be overcome by greater exertion, the race tends to deterioriate; sometimes the more active and energetic members migrate to more favourable regions, leaving a residue of a lower grade of energy and intelligence behind; sometimes it is the lack of nutrition of the body and mind that leads to the deterioration or even extinction of the race. As to the effect of disease, the results will vary. If the disease

is short in duration, though severe, and no harmful sequelæ are left behind, the effect may be, on the whole, beneficial, for by the disease the weakly will be eliminated and the resistance of the race to the disease will be increased. Doubtless in the past good has been done by disease, for by it a sifting of the strong from the weak has taken place. The result, however, is very different if the disease does not kill but leaves behind it permanent sequelæ, which weaken and disable those who have suffered from it, and the more intensely the disease attacks a community, and especially if it be endemic, the greater the harmful effects. In many of these cases racial immunity is not established, at all events not within thousands of years, so that the race reaps no benefit from the disease; and not only is the race no better, it may be far worse. For if all, or even a large percentage, of the younger inhabitants of a country suffer from a disease which leaves them feeble both mentally and bodily, the race will, without doubt, deteriorate.

Major Ross tells us that he has seen whole villages destroyed by the parasite of Kala-azar. Until comparatively recently the population of most European countries increased very slowly. Some of the enormous loss of life that this slowness of increase must mean was due to war, some was due to famine, but by far the greatest share of it must be put to disease. Yet unless the disease is one leaving long-lasting weakness behind it, the disease may do no permanent harm to the people as a whole; but if it leaves behind permanent impairment of mind or body, especially if the disease be endemic, its effects on the people may last for ages.

To any one acquainted with these facts it must appear almost self-evident that disease must exert an enormous influence on the course of nations, and that this influence must have been frequently of greater importance than wars or rulers in shaping the destinies of peoples. The historian has indeed given credit to disease when it has intervened in the course of a military expedition, and he has recognised that an epidemic among the troops of an army may have been the turning-point of a campaign. The Walcheren expedition was well conceived, and it owed its utter failure almost entirely to the disease which assailed it. Had it succeeded in destroying Napoleon's great dockyard on the Scheldt it would have had a very wide influence on the course of the war.

Yet more; the supremacy of a nation strong, wise, and healthy may be destroyed by the appearance of an endemic disease which saps the life-blood of the people, and there is much foundation for the assertion that the downfall of Greece was really due, not so much to the superiority of its enemies as to the introduction of malaria into the country. At the present time Greece is extremely malarious. Major Ross examined many of the inhabitants in the Copaic plain, which has replaced the lake drained in 1893, and he estimated that quite half of the children were infected with malaria, even in June, before the annual malaria season had commenced, and this district of Greece is not alone in being intensely malarious. It has been estimated that in the year 1905, out of a population of about two and a half millions nearly a million people in Greece were attacked with malaria, and nearly six thousand died. It is clear, then, that though some parts of Greece are comparatively

healthy, the country as a whole is extremely malarious. The question then arises whether it has become infected with the disease within historic times. It is a little difficult to imagine that the Greeks in the height of their intellectual supremacy could have been a people saturated with malaria. Can it be that a nation degraded physically and mentally by malaria should be capable of creating the masterpieces of the Golden Age of Greece? If, then, we have to confess that it is unlikely that the Greeks in their prime were malarious, we have to solve the question: When was malaria introduced, and is its introduction into Greece to be held responsible for the degradation of its people?

Mr. W. H. S. Jones has studied this matter from the historical side, and he has set himself to solve the problem of the date of the introduction of malaria into Greece. He has made an elaborate investigation into the references by classical writers to diseases which may reasonably be considered to have been manifestations of malaria. It is quite certain that malaria existed in ancient Greece. The references to it are numerous, and so clear that no doubt can be felt on this point. From the year 400 B.C. there is a large amount of evidence that in Greece the disease was widely prevalent. When the question of the date of the introduction of malaria is considered, it is fairly clear that there is no reference to any disease which can be malaria before the middle of the fifth century B.C.

It cannot be proved that malaria did not exist in some parts of Greece even earlier than this, but it seems fairly certain that it was absent from Attica. If, then, malaria was introduced, whence did it come?

Mr. Jones suggests that as its appearance seems to coincide with the Greek expedition to Egypt in 456 B.C., that may have been the channel through which the disease entered Greece, the returning soldiers bringing the disease with them. The fact that in ancient Greece malaria certainly attacked adults is very suggestive that the infection of the country was recent.

If these suppositions are correct, did the introduction of malaria have any effect upon the Greek character? There appears to be reason for thinking that the Greeks had noticed that malaria tended to make patients neurotic, and it is at least possible that the gradual change which certainly did take place in the Greek character by the end of the fourth century B.C. was due to the gradual effect on the whole people of endemic malaria. At all events, we are justified in thinking that the gradual change in the Greek character from the beginning of the fourth century was one which would certainly have been aided by, and was in all probability caused, partly at least, by malaria.

Another point is worthy of attention. When malaria appears to have become prevalent in Greece, large numbers of Africans and Asiatics were being poured into the country as slaves, and as many of these were already immune to malaria, they would be more likely to survive, while the native Greeks would gradually tend to be eliminated. Thus the disease would bring about a change of population which in itself must have had a marked effect on national character.

In discussing the question of the introduction of malaria into Italy we have fewer facts on which to depend than we have in the case of Greece. The

earliest Roman physician, Celsus, did not write till the first century A.D., and we are quite sure that malaria existed in Italy long before that. On the whole Italy is, for the most part, not so well adapted to the growth of the mosquito as is Greece.

From 50 B.C. malaria was certainly common in many parts of Italy and even in Rome itself, and it is possible that its prevalence in Rome was due to the fact that, in all the larger houses, in the atrium or main room there was a hole in the centre of the roof which let in light and also admitted rain into a small cistern (the impluvium) in the middle of the room, and thus each Roman house possessed a pool of stagnant water extremely suitable for a breeding site for the mosquito.

There is some evidence that malaria existed in Italy for at least a century before this, but it is fairly certain that many parts which are now extremely malarious were not always so. No part of Italy is more infested with malaria than is the Campagna, and yet, from the accounts we possess of its population, it must have been healthy until the beginning of the second century B.C.

What was the effect of malaria on the Roman character? North, in his work on Roman fever, has said, "The effect of the disease on the people is to unfit them for labour, to cause loss of time, loss of money, and generally to diminish their producing powers, whilst at the same time the race, if left to itself, tends towards moral and physical degradation;" and again—"Malaria is perhaps the most incapacitating disease to which man is liable."

It is certain that at least from the second century B.C. malaria was endemic in Rome, and a careful

study of history will show that there was a definite degradation in the national character in spite of the constant introduction of fresh blood from the healthier races. The extravagant cruelty and the absence of soberness and self-control seen in the Roman society of the first century A.D. may well be explicable as the result of malaria. Even in the present day the brutalities committed by some white men in tropical countries are in part due to the baleful influence of malaria, and that a similar explanation is applicable to Rome is extremely probable.

Although it cannot be maintained that the degradation of Greece and Rome was due entirely to malaria, yet sufficient has been said to show that in the appreciation of the causes of the degradation which certainly did exist, sufficient attention has not been paid to the influence of endemic diseases; and the study of this subject has also a lesson for us at the present day; for it must be appreciated that the occurrence of diseases like influenza, which attacks many more subjects than it kills, and leaves many of them permanently weakened in mind and body, cannot fail to exert a very pernicious influence on the national character.

Many of the older physicians who saw the influenza epidemics at the end of the eighteenth and the beginning of the nineteenth centuries maintained that the constitution of the inhabitants of this country had changed; for it was no longer possible to treat patients with the energetic and drastic methods of treatment which had been adopted earlier. It is always difficult to be sure of the truth in matters such as this, but there is much evidence in support of the idea that something had indeed weakened the physical endurance

of the people of this country in the early years of the nineteenth century, and those who know the weakening effect both on mind and body of an attack of influenza will be the first to acknowledge that, should influenza become permanently endemic in the country, it may have far-reaching effects on its inhabitants. Influenza causes an irritability of temper, a peevishness of disposition, a persistent discontent, which, if rendered long-lasting by frequent attacks, must exert a most pernicious influence on the mental condition of the patient.

The strain on the nervous system exerted by influenza cannot be denied, and whether the disease will pass away for many years, as it did from 1850 to 1889, or whether it will become really endemic, may have most important influences on the British character and the destinies of this country.

That malarial disease may change the whole aspect of a country is well shown by what has happened in Mauritius. Before 1866 Mauritius was an ideal health-resort, and many from India used to land there to recover; but in 1866 malaria was introduced, and in the following year it spread through the whole island, destroyed some 30,000 people, and caused a great strain on the finances of the island.

CHAPTER XXI

THE RÔLE OF INSECTS IN THE PRODUCTION OF DISEASE

One of the most striking advances in our knowledge of the mode of causation of disease is our recognition of the important part which many insects take in giving rise to various maladies. As might have been expected, the insects are more important in this connection in the tropics than in the cooler portions of the globe, for the hot climate favours the multiplication and the rapid development of insects, so that they abound to an extent which is hardly realisable by those who are unacquainted with hot countries. It must be acknowledged that insects are not wholly harmful to man. We know that the fertilisation of many plants can only be accomplished if certain definite insects are present which can carry the pollen from one plant to another, and that if an attempt is made to grow these plants in a district where those special insects are not to be found, the plants, though they may grow in great luxuriance, can never set their seeds.

Great though may be the benefits which can be derived from insects in this matter of the fertilisation of plants, grave doubts may be felt whether, on the whole, we do not suffer more harm by their influence in producing disease then we derive good from their presence.

The Rôle of Insects in Disease

It is hardly necessary to say that the insects which help us by assisting in the fertilisation of plants are not the same insects which give rise to disease.

Human beings are not the only sufferers from insects. Some of the most troublesome affections attacking lower animals are caused through the agency of insects. More than a dozen diseases affecting the human body can with certainty be ascribed to the agency of insects; and at least the same number of diseases affecting the lower animals must be set down to a similar cause.

There are three ways in which insects may prove harmful. In the first place some insects are true parasites. They exist on or in the skin, or they even burrow down into the deeper tissues; and these diseases are of no small importance. As an example may be mentioned the itch insect which causes scabies. I do not, however, propose to say more about them.

In the second group of diseases associated with insects we may put those diseases in which the insect acts merely as the mechanical transporter of an infective agent. Thus, flies may settle on material contaminated with the germ of typhoid fever; later, they may stop to feed on milk, bread, or some other form of food, and their feet, which have become contaminated with the typhoid germs, will deposit this germ on the food they touch. That this method of transmission of disease really does occur has been shown by experiment. A fly has been allowed to walk on some material containing infective germs, and then it has been made to tread on the surface of a glass plate covered with a thin film of a material suitable for the growth of germs. This plate has been kept at a suitable temperature in an incu-

bator for the development of the germs, and then, at every spot where the fly's feet have trod, there has developed a minute group of the infective germs, and these groups soon grow large enough to become visible to the naked eye.

It is probable that a large portion of the typhoid fever, which slew so many thousands in the South African War, was caused by the contamination of the food from the swarms of flies which infested the British camps.

Typhoid fever is for the most part produced by the drinking of contaminated water or milk, yet we are now certain that in special circumstances contamination of food by flies may be of at least equal importance.

The common house-fly assumes a position of greater importance in our eyes than heretofore because of this power of being the means of transmitting disease, and it is not improbable that many other affections are conveyed in a similar manner by the common house-fly. It is therefore a matter of importance that means should be taken to prevent the breeding of flies, and the most simple method by which this may be done is by taking care that suitable breeding-places are not allowed to exist.

Flies will breed in any heap of decomposing organic material, in dust-bins and manure heaps, in fact in any heap of rubbish, and therefore precautions should be taken to prevent the existence of such heaps longer than is necessary. As much as possible they should be removed far away from dwellings, or they should be covered with a few inches of earth or sprinkled with some antiseptic solution. If these precautions be taken, the number of house-flies will be noticeably

diminished, and the result will add not only to the comfort but also definitely to the health and safety of the dwellers in the house.

There is yet a third way in which disease may be introduced by the agency of insects, and that is, insects may act as the "intermediate hosts" of germs which can infect the human body. This will require a little explanation.

Many forms of animals, especially parasitic animals, exhibit what is called an alternation of generations: thus, for instance, the ordinary tape-worm which inhabits the human body has two forms of existence. In one it exists as a minute worm-like body in the muscles of the pig, and when the pork is examined it is seen to be speckled all over with little spots, and in this condition it is called popularly "measled" pork. In this form the worm is so small that it can hardly be seen with the naked eye. The white speckle, which is seen, is the worm surrounded by a capsule. When this pork is eaten by men or dogs, either uncooked or cooked insufficiently to kill the parasite, each small worm develops in the intestine of its host into a tape-worm, which as long as it remains alive continues to form daily many hundreds of eggs. These eggs are thrown off, and in time become swallowed by a pig, and the egg then develops into a minute worm, which passes from the stomach of the pig into the muscles, where it lies dormant until that pork is eaten by men or dogs. Thus, this form of tape-worm has two phases of life, one of which is passed through in the pig and the other in the alimentary canal of the man or the dog.

I have described the life history of one of the most common forms of tape-worm in order that the reader may understand what is mean by an "alternation of

generations." Many parasites have in this way two existences, one of which is passed in one animal and the other in another animal. In each stage the parasite inhabits that animal which is most suited for it, and it cannot pass through that stage in any other animal. Thus the life history of the tape-worm will help the reader to comprehend the life history of the germs of malaria and of the parasitic causes of several other very serious diseases.

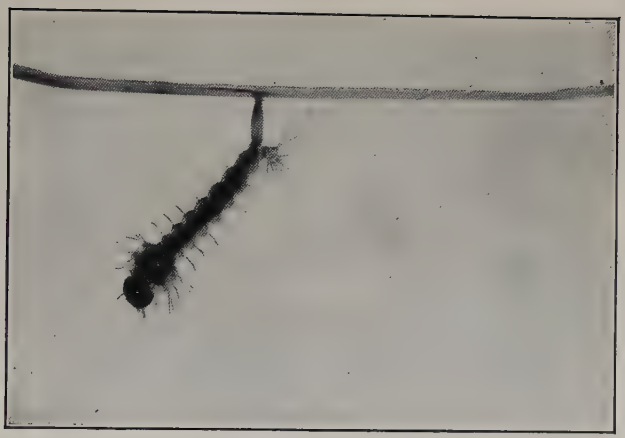
All the insects belonging to this class live by sucking blood. The insect pierces with its proboscis the skin of a man or other animal on which it feeds. The proboscis is hollow, and the insect sucks up and swallows the blood and lives on it. In some cases the insect cannot live in any other way. If the individual who has been "bitten" by the insect is healthy, no special result follows; but if, on the other hand, he is suffering from malaria, his blood will contain a number of the parasites which cause that disease, and when the insect swallows some of the blood, it will swallow also some of these parasites. When the blood enters the stomach of the insect, it undergoes digestion, but the parasites are capable of withstanding the action of the digestive juices of the insect. They make their way through the stomach wall and reach the muscles and tissues of the insect. Here they pass through certain changes, which differ according to the nature of the parasite; they grow and develop, and ultimately make their way into the proboscis of the insect, and then, when that insect pierces the skin of another person who is healthy, some of the germs from its proboscis are introduced into the blood of the healthy man, and thus he becomes infected by the parasites. So that in this case also, as in the case of the tape-

worm, two hosts are necessary for the development of the germ. One state of the existence is passed in the blood of the human body and one within the body of an insect. In order that the reader may understand fully the life history of these parasites and their relation to disease I will describe the case of malaria.

Malaria is always spread by the agency of certain mosquitoes.

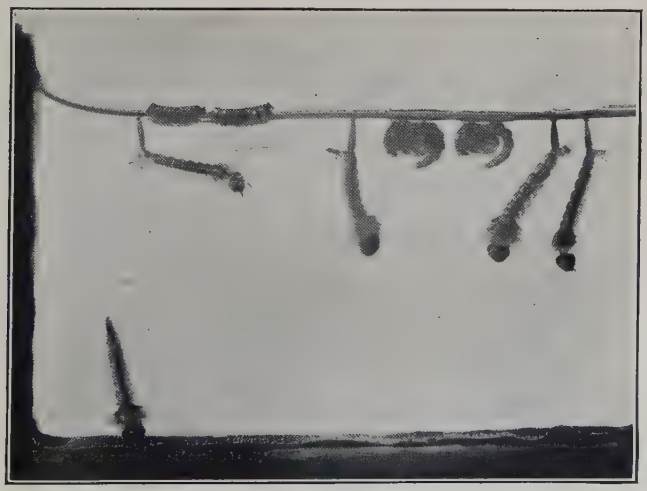
Mosquitoes are small dipterous insects, that is to say, they have two wings, and they belong to the class Culicidæ. Several hundreds of varieties of mosquitoes are known, but fortunately only comparatively few of them are capable of assisting in the spread of disease. The mosquito cannot develop where there is no water, and this is a point of great importance in the problem of the prevention of malaria. The eggs must be laid by the mosquito on water, and unless water is present they cannot hatch, therefore mosquitoes cannot exist in large numbers in any locality where there is not much stagnant water. The water may be in the form of pools or swamps, or it may be in rain-water barrels or in tanks, and different kinds of mosquitoes differ in their requirements. Some only lay their eggs in very small pools, or in the water collected in an old meat-can; others require larger pieces of water, but in all cases the water must be stagnant. Not only is it necessary that there should be water for the laying of the eggs of the mosquito, but water is also necessary for their development. Two of the stages of the insect are free swimming forms, and therefore water is essential to enable the insect to pass through those stages.

The eggs of mosquitoes are laid differently accord-



LARVA OF MOSQUITO

With a "syphon tube" through which it breathes.



MOSQUITO LARVÆ (ANOPHELES)

Resting and breathing at the surface of the water.

ing to the species. The special mosquito which causes malaria belongs to the family of Anophelinæ, and these always lay their eggs singly. The Culicinæ, which are much more widely spread, lay them in masses, and they are sealed together with an adhesive material so as to form a boat-shaped mass, which can float upon the surface of the water. It cannot sink, but every breeze blows it along. Some of these boat-shaped masses may contain as many as four hundred eggs. Even when the eggs are laid singly, each is so shaped that it will float, and for this purpose at each end of the egg is a hollow cavity, which keeps the egg, like a lifeboat, from sinking or even from upsetting.

When the weather is sufficiently warm, the egg hatches in two or three days, and then the "larva," which is the next stage of the insect, comes out and swims about, feeding on the minute organisms in the water. All the mosquito larvæ breathe air, but the breathing apparatus is arranged in two different ways according to the species. In some there is a special little tube, called a syphon tube, which is held so that its upper end is just above the surface of the water. The other kind of larva, which has no syphon tube, has to lie close to the surface of the water, so that a little hole in its body may just touch the surface, and through that hole the air passes into the interior of the body. The fact that the larvæ of the mosquitoes breathe on the surface of the water is of importance, for if some paraffin is poured upon the water, it is clear that the larvæ will not be able to breathe and will be suffocated, and this method is of some value in killing mosquitoes. After the larva has existed for some time it develops into the next

stage of the insect, and is called a "nymph" or "pupa." During this stage no food is taken, though the pupa has to breathe, and this is done through a pair of syphon tubes which rest a little above the surface of the water. During the two days which are occupied by the nymph stage, changes of structure are going on in the interior of the body of the animal. When the time has come, the mosquito bursts the skin which covers it and emerges in the form of the fully developed insect, or mosquito. For a few hours the insect rests upon the empty case, while its wings are drying as it floats about on the surface of the water, and at length it flies away.

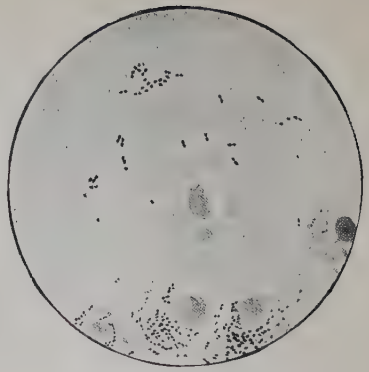
All these changes can be seen in England as well as in tropical climates, for most of the "gnats" in this country are really mosquitoes in everything but name.

As to the structure of the mosquito it will not be necessary to say much, but the proboscis deserves a description. It consists of many parts. The lip forms a sheath, which surrounds the six "stylets" or piercing organs, which are very fine, sharp needles, and there is a very fine tube, the "hypopharynx," through which the saliva of the insect is carried into the wound that has been made by the stylets.

The habits of the mosquito are of great importance, as by a knowledge of the customs of the insect it is more easy to avoid its attacks and to destroy it. As the habits of different species of mosquito differ, I will describe mainly the habits of the Anopheles, which is the agent in the spread of malaria.

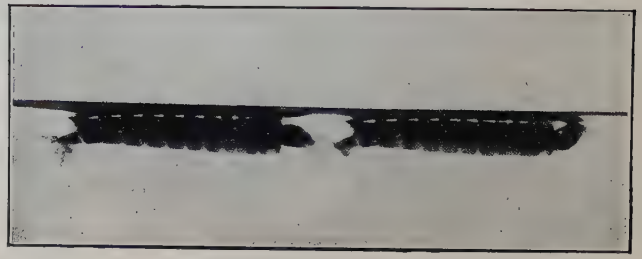
The mosquitoes do not like the light, and therefore they hide during the day in any convenient dark spot, but as soon as it begins to get dark, they come

EGG OF MALARIAL MOSQUITO (ANOPHELES
Dorsal view.



THE BACILLI OF INFLUENZA
(Magnified 530 times).
It will be noticed that many of them are in pairs.

EGG OF MALARIAL MOSQUITO (ANOPHELES)
Side view.



MOSQUITO LARVÆ (ANOPHELES)
The one on the right side is feeding

out from their hiding-places and begin to search for their food. Some mosquitoes prefer to live away from dwelling-houses, and only attack those who come into the neighbourhood of their swamps, but others may be called domesticated, for they like to dwell in houses, hiding in the folds of the clothes, or among the rafters. When night comes the mosquito leaves its hiding-place and hunts for a human being on whom it may prey, and as it flies about it makes a very striking buzzing sound. As soon as the insect comes to rest on the skin, it pierces the skin and feeds upon the blood.

It is important to bear in mind that it is only the female mosquito which feeds on blood, for the diet of the male insect in confined to the juices of succulent fruits such as the banana. A mosquito does not live long, its average length of life being about two months.

The Malaria Parasite

There are several varieties of parasite which cause the several kinds of malaria, but it will be unnecessary to describe more than one, for they are all so very much alike.

It belongs to the lowest form of animals, for it is quite certain that it is an animal, and not a bacterium. It is called the *Plasmodium malariæ*. In the course of its life it undergoes several changes of form, and this will be most easily understood by an account of the life of the germ at its start in the blood of a healthy man who has just been bitten. When a mosquito infected with the plasmodium "bites" a man hitherto unaffected with the disease,

the stylets pierce the skin, and the parasite passes along the minute tube called the hypopharynx with the saliva, and so it reaches the blood of the person bitten. At this stage it is in the form of a minute spore, and is called a "sporozoite." As soon as the sporozoite reaches the blood it pierces the wall of a red corpuscle and makes its way into the interior of it. The parasite then begins to grow at the expense of the corpuscle in which it is. When the parasite has destroyed the whole of the red corpuscle, it divides into a very large number of parts, called metazoites, which escape from the destroyed red corpuscle; then each of the smaller parasites enters a red corpuscle and the process of destruction of the corpuscle is repeated. In this way many thousands of the red corpuscles are destroyed. At the same time the parasites are giving rise to toxins, and in this way the fever is produced, while the destruction of the corpuscles leads to the anæmia. It has been calculated that two hundred and fifty million parasites may be present in the body during an attack of fever.

If a mosquito only recently emerged from the pupa stage comes and attacks a man who is suffering from malaria, and drinks some of his blood, it is clear that with the blood there will pass into the stomach of the insect a number of the malarial parasites. In the mosquito's stomach the blood undergoes digestion, but the germ can resist the digestive juices of the mosquito, and it makes its way through the wall of the stomach into the tissues of the mosquito, where it passes through several changes and ultimately divides into very many minute bodies called sporozoites, and these make their way into the salivary glands

of the mosquito, so as to be ready to be injected with the saliva of the insect into the next person bitten.

Thus the cycle of the life history of the *Plasmodium malariæ* is complete, and we have returned to the point from which we started. The outbursts of fever correspond to the destruction of the red corpuscles and the sudden discharge of the metazoites and toxins into the blood stream.

CHAPTER XXII

THE RÔLE OF INSECTS IN THE PRODUCTION OF DISEASE (*continued*)

Yellow Fever

Yellow fever is an acute disease confined to hot climates, and especially associated with Central America. It was probably endemic there long before it was ever heard of, but it was not until the middle of the seventeenth century that its appearance was first recorded. Its distribution is almost confined to the sea-coast and the districts close to the sea. Occasionally cases are introduced into temperate climates, but they always fail to spread, and more than a century ago it was recognised that it was not infectious. Jamaica at one time was much infested with the disease, but it was found that it was possible to escape the fever by removing to the hilly districts during the hot season, and since that has been done, the disease has almost disappeared, for the native negroes who remain at the sea-coast are immune, through having passed through an attack. The mode of transmission of the disease has been a matter of dispute for very many years; and it was not until 1901 that proof was obtained that the bite of a mosquito was an essential element in the transmission of yellow fever. This was shown by a long series of experiments, by which on the one hand it was

found that those who were bitten by a certain mosquito which had previously bitten a man suffering from yellow fever, contracted the disease, while on the other hand those who had been exposed to similar conditions, except that they had not been bitten by such mosquitoes, did not suffer from the disease. Unfortunately Lazear, who was experimenting on the subject, and was one of the first to be bitten knowingly by infected mosquitoes, died a few days later.

The mosquito responsible for the spread of yellow fever is named *Stegomyia fasciata*, and it has been shown that it is harmless for twelve days after becoming infected, so that it is certain that development of the organism is going on in the body of the Stegomyia.

Yellow fever differs greatly from malaria in one very important point. One attack of malaria does not immunise the patient against future attacks, but he can recover from one attack of yellow fever completely, and for ever after he is absolutely immune against any further attack. The mortality is very high.

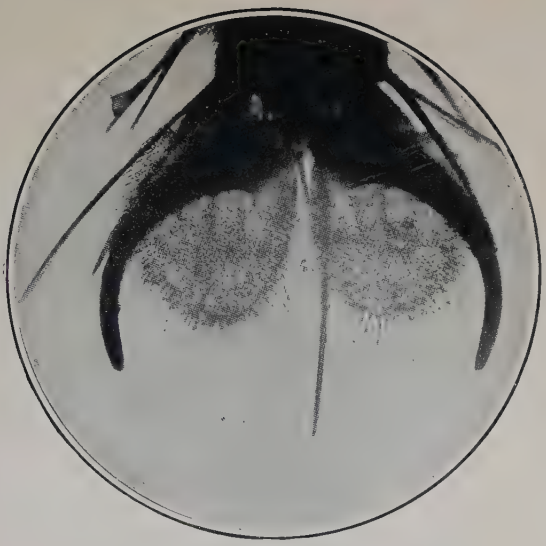
Preventive measures based on the fact that the disease is only transmitted by the Stegomyia have proved wonderfully successful. We have no certain knowledge of the germ of yellow fever.

Elephantiasis

In many tropical countries there is a disease called elephantiasis; it is so named from the great enlargement of the limbs which occurs, the legs being chiefly affected. Sometimes the legs are so much enlarged that the patient is hardly able to move about. The

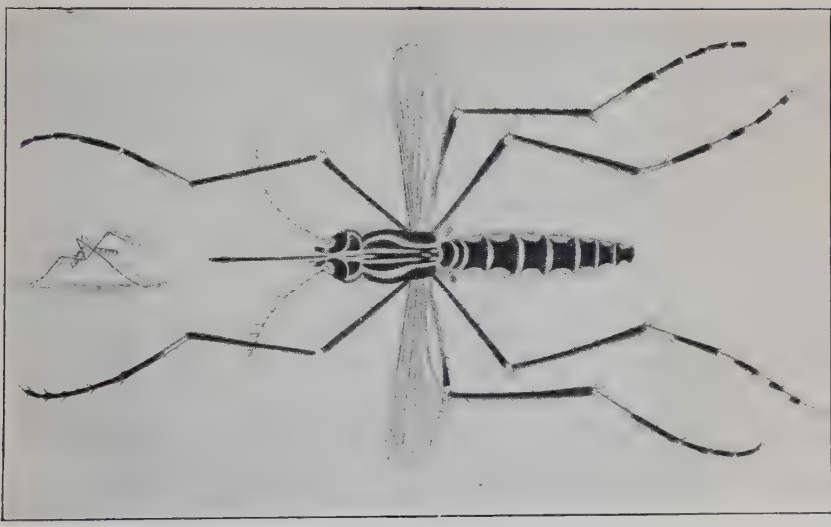
disease is common in the islands of the East Indian Archipelago, but it is found also in the West Indies and in some parts of South America.

The cause has long been known to be the blocking of the lymphatic vessels by a long, very thin worm called *Filaria brucei*, which lives in the lymphatic vessels, while the embryos of the worm live in the blood, where they can be found if looked for. Every person who has these embryos in his blood does not necessarily suffer from elephantiasis, for in those countries where the filaria occurs, very many people are found to possess the worm and yet show no sign of the disease. The number of filariæ in the body may be very numerous, and it has been estimated that there may be as many as forty million embryos present and yet no signs of disease appear unless the lymphatic vessels become blocked. Sir Patrick Manson found that the embryos appear in the blood and then disappear; and by careful watching he found that the filarial embryos begin to appear towards evening, increase in numbers during the night, and decrease in the morning. He also discovered a very curious thing. If the patient goes to bed during the day, and keeps about at night, the filariæ also change their habits and appear during the day and disappear at night. The object of this periodicity has not been ascertained, but it is possibly an adaptation of the habits of the filaria to the habits of the mosquito. For it has been found that the disease is caused by the bite of a mosquito; probably several forms of mosquito can serve as intermediaries, but the commonest form is a Culex. The mosquito bites a person suffering from filariæ and then the filaria undergoes in the body of the mosquito changes



FOOT OF HOUSE-FLY

Showing claws and hairs ; these fine hairs have a sticky secretion, to which bacteria adhere, and are carried to food on which the fly alights to feed.



MOSQUITO OF YELLOW FEVER (STEGOMYIA)

The small figure shows its real size.

analogous to those which the plasmodium passes through in the Anophelinæ, developing within the muscles of the insect and then making its way to the salivary glands, so as to be ready for the time that the mosquito makes its next meal.

Sleeping Sickness

The disease which is called sleeping sickness was until recently confined to the West Coast of Africa, but since that time it has spread far and wide in Africa. The disease begins with a feverish attack, later headache and anæmia appear, and after these symptoms have lasted for several months, or even years, somnolence comes on and the patient sinks into a state of complete unconsciousness and ultimately dies. The mortality is very high indeed, for recovery is very rare.

The disease is limited to the tropical regions of Africa, but in that region within a few years it has done a great deal of harm, destroying an immense number of people, and Europeans seem to be as liable to it as the natives.

In 1901 Forde of Gambia found that the disease was due to a special organism existing in the blood. This is a minute animal very low in the scale; in fact, it belongs to the same great class as the plasmodium, for it is a protozoan. It has been named *Trypanosoma gambinense*, and the disease is sometimes called trypanosomiasis. The germ is a long wormlike body, pointed at each end, and along the side of the animal is an undulating membrane, which ends anteriorly in a whiplike process called a flagellum, which, by means of wavy movements, has the power

of making the Trypanosoma move about in the blood among the corpuscles.

When it had been decided that the Trypanosoma was the cause of the disease sleeping sickness, it remained to be settled how it gained entrance to the body of its victims. It has been definitely proved that the micro-organism is inoculated into the human body through the bite of the fly called the tsetse fly, the *Glossina palpalis*. There are many varieties of tsetse flies, and one of them is the means of conveying to horses the organism which causes tsetse-fly disease, which has caused an immense loss in horses and cattle in many parts of Africa. That disease is also due to a Trypanosoma.

The tsetse flies do not seem to be able to exist far from water, and this limits, to some extent, the areas in which the disease can spread. Koch believes that the flies infest crocodiles and that is why they live near water. When a tsetse fly has bitten a person suffering from sleeping sickness, it is able immediately to infect a healthy man by biting him. It does not appear that there is any need for a prolonged cycle of changes in the body of the fly, though such a cycle of changes does occur.

The Plague

One of the oldest epidemic diseases is the plague, and it has on many occasions visited the British Isles; the best known visitation being that which occurred in 1665, the year before the Great Fire of London. At present it is mainly confined to Asia, though it is showing a tendency to travel farther afield. In 1894 Kitasato discovered the microbe which gives rise to

ARMED AGAINST THE PLAGUE IN CHINA

The doctor on the right is wearing the full working kit of linen, which can be boiled and disinfected easily, and he is breathing through a pad of lint soaked in carbolic acid.

the disease. It is a bacterium, and has been named *Bacillus pestis*.

It has long been known that when the plague has prevailed in any town or district, there has at the same time been a great mortality amongst the rats, and now we know that rats and some other animals can suffer from the plague. It seemed therefore probable that the rats brought the disease to a district, or at least assisted in spreading it. After much research it has been found that the agent responsible for spreading the disease to man is a form of flea. The flea that usually attacks human beings is called *Pulex irritans*, but the flea which is the agent in spreading the plague is a variety called *Pulex cheopis*. When a rat which is suffering from the plague is bitten by a flea of the kind called *Pulex cheopis*, which is the form that affects the black rat, the flea, with the blood which it sucks up, will take into itself some of the plague germs. So long as that rat lives, its fleas have very little tendency to leave it, but as soon as the rat dies, its fleas forsake it at once and seek another host ; this may be another rat, or, if no other rat is available, they will attack a human being ; but whether they attack a rat or a man, the one bitten will suffer from plague.

The *Bacillus pestis* has been shown to exist in a flea that has bitten a rat suffering from the plague. If a healthy rat be put into a cage with a rat suffering from the disease, it will not contract the disease if care has been taken to free both rats from fleas. If, however, the affected rat is allowed to retain its fleas when it is shut up with a healthy rat, the disease will be transmitted to the healthy rat as soon as the fleas pass from the affected rat to the healthy rat, and that will be probably as soon as the sick rat dies.

When the *Bacillus pestis* is in the stomach of the flea it is able to grow and increase in numbers, but it does not undergo any other change.

There is another point that helps to spread the plague. When any rats are taken ill, their natural tendency appears to be to leave the neighbourhood, and thus the affected rats take the disease with them to places previously healthy.

The plague appeared certainly in Egypt nearly two thousand years ago, and it is probable that it had visited the country long before that. Surprise has often been expressed that in ancient Egypt cats should have been an object of worship. The suggestion has been made that it had been noticed that the plague was not so likely to attack houses where cats were numerous, and therefore the cats had been looked upon as supernatural and had been considered worthy of worship. Whether there is any truth in the suggestion or not cannot, of course, be decided, but it is at least not very improbable. It is at all events certain that rats are responsible for introducing the plague into most countries. Therefore attempts should be made to exterminate rats completely, or, if this is not practically possible, at least to reduce their numbers greatly. A determined effort should be made, and it must be a general effort, extending over the whole of the country; for if it is limited to a very few districts, the rats will leave those places where they are being troubled and will seek for some part of the country where they can be at peace.

When a ship carries wheat or any form of grain, it has always a large number of rats on board, and if that ship should come from a port where there have been cases of plague there is a very great probability

that the rats on board will be affected with the disease. Even if the port of origin of the ship should be plague-free, if the vessel should in the course of a voyage touch at a port where there are cases of the plague, there will be a very great risk that the disease will be carried by the ship.

All vessels coming from infected ports should be placed in quarantine until the rats and their fleas have been examined for the *Bacillus pestis*. Care has to be taken that rats do not escape to land from the quarantined vessels, carrying with them the germs of the disease.

There are many other diseases of importance, some of them affecting man and some of them affecting the lower animals, which are due to insects, but it is unnecessary to mention any more instances. Enough has been said to show that many insects are to be held responsible for spreading many serious maladies, and that the best method to prevent any of these diseases, is to get rid of the insects which are its promoters.

CHAPTER XXIII

THE FIGHT AGAINST MALARIA

In preceding chapters I have described with some fulness the devastation which has been wrought by the prevalence of malarial disease in certain countries. I have traced the mode in which the disease arises and is transmitted, and I have shown how the very existence of the disease is dependent on certain physical conditions.

As soon as our knowledge of the mode of the origin of the disease began to be complete, attempts to utilise this knowledge for the prevention of malaria were made, and in this chapter I give an account of the chief methods that have been adopted for this purpose and I describe the measure of success which those efforts have met with.

Should it be possible to eradicate malaria and other kindred diseases from the tropical regions of the earth, a great increase in the area habitable by white men would be obtained. Although the tropical heat and the intense glare of the tropical sun are not specially suited for white races, and though, as I have elsewhere mentioned, the intensity of sunlight may in itself prove harmful to those unprovided with a fully pigmented skin, yet with a few and comparatively simple precautions it is possible for white men to live in health and comfort within the tropics, provided

only that malaria and the allied tropical diseases are not present.

The importance, therefore, of making great exertions to put an end to the dominion of malaria cannot be disputed, and the success which even now has been obtained demonstrates clearly the wisdom of this effort. Many of the measures which have been adopted for the prevention of malaria are almost equally applicable to yellow fever and some other insect-borne diseases, but in this account I shall speak especially of those procedures which experience has shown to be of chief value in the prevention of malaria.

In the territories of ancient Rome many great drainage works were carried out in districts which are now extremely malarious, but it is at least doubtful whether this drainage was intended to prevent the malaria or to render the land fit for agricultural purposes. It is nevertheless a fact that, when the drainage was neglected and the canals were allowed to silt up, malaria appeared, and even to the present day it has prevented the utilisation of extensive districts for agriculture. Whatever may be the truth in regard to the ancient drainage works, it has for centuries been known in Italy that drainage and similar measures have a very real control over the occurrence of malaria.

When in our own time the mode of origin of malaria had been conclusively traced to the bites of mosquitoes, the question arose whether it might be possible, by controlling the breeding of the mosquitoes specially concerned, to limit the extent of the disease. Major Ronald Ross in 1884, while at Bangalore in Southern India, noticed that mosquitoes were much

reduced in number in his house, when he took care that rain-water was not allowed to remain in tubs and pots in the garden. Later, in 1897, Major Ross observed that the larvæ of the Anophelines, the mosquitoes which are connected with malaria, did not breed in the tubs and pots where other mosquitoes, Culex and Stegomyia, bred, but mostly in pools of water on the ground. Thus he perceived the explanation of the fact that malaria is especially connected with pools and marshes. He noticed that the Anophelines bred, not in large areas of water such as lakes and reservoirs and not in tubs, but generally in small, shallow pools, and that, like other mosquitoes, they were most prevalent near their breeding-places. He endeavoured by writing and by practical attempts to carry out the measures suggested by these observations. He maintained that it might be possible to remove all opportunities for breeding of mosquitoes from the towns, even though such attempts might be impracticable in a water-logged district, and he laid down the rule that it is one of the first sanitary duties of all municipalities and town councils in warm climates to keep down, as much as possible, the numbers of mosquitoes within the area placed under their care; for it is certain that, if a municipality can afford to have a water supply laid on and a system of sewerage, it can surely afford the expenditure of money necessary to render it free from malaria and other similar insect-borne diseases.

He went with two others to Freetown, the capital of Sierra Leone, on the West Coast of Africa, to study the matter on the spot, and to see what could be done. Two local mosquitoes, Anophelines, were

identified by him as carriers of malaria, and then their habits were studied with the object of working out a plan for the reduction of the number of mosquitoes. The main facts connected with the habits of the Anophelines were discovered, and the broad distinctions between them and the Culicines were pointed out.

The publication of the results of these researches gave a great impetus to the work of the prevention of malaria. Little was, however, done at Freetown beyond appointing a single person for a few months to check the mosquitoes. In 1901 Major Ross with the help of some friends made an attempt to reduce the number of mosquitoes at Freetown, for he had become convinced that anti-malarial campaigns had better be conducted not only against Anophelines, but against all kinds of mosquitoes at once, for by that time it had become known that yellow fever was conveyed by a mosquito, a Stegomyia. He engaged the services of twenty men, and the Governor of Sierra Leone added twelve to the number. With the help of these, large quantities of mosquito-breeding rubbish were removed, and many Anopheline pools were filled up or drained. This work made a great reduction in the number of mosquitoes, but the local authorities did not appear to be willing to continue the measures of prevention, and the work was allowed to lapse.

In 1902 Major Ross was asked to go to Ismailia to advise what should be done to prevent malaria. When Lesseps made the Suez Canal, he founded the town of Ismailia; he intended it to be an important city, and he placed it on a small salt-water lake, Lake Timsah. He placed the headquarters of the Suez

Canal Company there, houses were built overlooking the Canal, and public gardens were made. Boating was possible, and bathing, free from sharks, and shooting could also be had. As the town was in the desert and not near any other town, it proved to be very healthy, and the Company did all it could to make it a perfect city. The water supply of Ismailia came by a fresh-water canal, made in 1877, connected with the Nile. Five years later the canal was deepened to allow boats to use it to pass from Cairo to Ismailia. The water contained a good deal of solid matter, and, as it was used to water the gardens and parks, the vegetation grew well. For a time all went well, but the water was allowed to run to waste, and marshes and ponds formed near and even in the town itself.

Soon after the marshes had formed, mosquitoes appeared, and a little later malaria appeared also. In the first year, 1877, three hundred cases occurred in the months from August to December. By 1891 the number had increased to nearly 2500, and attempts were made to prevent the disease by partial drainage of the marshes, but this was in the days before the mosquito theory of malaria had been formed.

The population of Ismailia had at one time reached 10,000, but the advent of malaria changed everything. There was so much sickness that the work could not be done, and trade came to an end. It was resolved to move the offices of the Canal to Port Said, and the town diminished in population.

An attempt to control the disease by the free distribution of quinine had been made, but it had not proved successful.

So in 1902, when Major Ross went to Ismailia to

see what could be done to prevent the prevalence of the Malaria, he advised that an attempt should be made to exterminate the mosquitoes, which were both Culicines and Anophelines. The chief places for the breeding of the mosquitoes were shallow pools resulting from the irrigation, and there was a cesspool under every house. There were no mosquitoes in the fresh-water canal, for the water was always flowing, but near Ismailia the canal leaked and a marsh had formed, and in this marsh larvæ of mosquitoes were found. The marsh was drained so that it could no longer harbour mosquitoes, and all the pools were filled. All the irrigation conduits, both great and small, were cleared of weeds so that the water was able to flow rapidly. The water to each garden was allowed to flow only as long as necessary, and then the supply was stopped. Every house was visited once a week, and petroleum was poured over the surface of the cesspools. All tubs and other vessels containing water were regularly emptied, and a fine was put on all failures to report collections of water which had not been treated. To carry out these measures only four officials were employed.

The results were very wonderful. In 1900 there were 2284 cases of malaria. In 1901 there were 1990 cases. In 1902 the number was 1551. In the next year the number had fallen to 214. In 1904 it was 90, in 1905 there were 37 cases, and since then there have been no cases in which the disease had been caught in Ismailia. It is true that cases are still occasionally introduced into the town from villages on the fresh-water canal at a distance from Ismailia, but the disease never spreads in the town itself, for there are no Anophelines there.

The Panama Canal

The work which has been done in the neighbourhood of the Panama Canal deserves mention. The canal measures some forty-two miles from shore to shore; for about two-thirds of this distance the country is mountainous and for one-third low and swampy. The railway between Panama and Colon is about forty-seven miles long, and a population of about 80,000 persons lives within half a mile of the railway. The whole length is divided into eighteen districts, each in charge of an inspector, and each inspector has about fifty men under him. The anti-malarial work performed there comprised several operations, of which the most important was drainage. The inspector had to drain and do away with all pools within 200 yards of every village, and the most effective and economical method appears to be sub-soil drainage.

Secondly, all undergrowths have to be cut down within 200 yards of the villages, the grass not being allowed to be more than a foot high. This is considered of importance because the adult mosquito cannot cross a cleared area of 100 yards. The application of petroleum is also employed where drainage is either impracticable or too costly, as on the edge of a swamp. The oil must be thin enough to spread readily, but it must not be too thin, or it will evaporate too soon.

The use of "larvicide" is also of importance. On the grassy edge of ponds or streams oil will not spread, and Anopheline larvæ breed there readily. In such a place a liquid is used which is poisonous to the larvæ. The form used consists chiefly of car-

bolic acid and caustic soda. In the Panama district quinine is distributed freely; it is given without charge to any one applying at any dispensary, and it is placed on all hotel tables and mess tables. There are also quinine dispensers who visit the various squads of negroes at work and offer every one quinine. In one year more than three thousand pounds of quinine were employed. Lastly, all Government buildings are screened so as to keep them mosquito-proof.

The results have been very gratifying, and the value of the measures undertaken has been fully proved.

Havana

The prophylactic measures which were undertaken at Havana were mainly directed against those mosquitoes which produce yellow fever, yet, with the removal of the yellow fever, malaria has disappeared also.

It will be clear from the preceding account of the work that has been done that there are many methods which are of value in the prevention of malaria. The relative importance of these will vary somewhat according to the local conditions. In most marshy districts the measure which must be considered of the greatest value is drainage, for by drainage marshy land can be rendered dry, but the extent and therefore the expense of any drainage operations must depend greatly on the area to be treated. Where possible, covered drains are much more effective than surface ditches, for ditches, unless lined with tiles, become easily choked by the rapid growth of tropical vegetation, and a sudden heavy shower may entirely destroy a ditch. The covered

drain will of course be much more expensive at first, but it will rarely require cleaning, while the surface drain, though economical in construction, requires much more frequent attention.

All receptacles of water require to be kept covered or empty; flower-pots and water-tubs must not be allowed to hold rain-water or must be covered, and even hollows in trees that may catch water must be filled up. All pools must be filled in, and care should be taken that no empty tins are allowed to lie about, in which rain-water might accumulate.

The next most important point is that if there is any moist or watery area which cannot be drained or cannot be filled in, it must be covered with petroleum. This forms an impervious layer and prevents the breathing of the larvæ.

It is desirable that the minimum amount of undergrowth be left in the neighbourhood of houses, for the less the undergrowth the more readily the ground dries and the greater difficulty the mosquitoes find in reaching houses from swamps at a distance.

Antiseptics such as carbolic acid can also be used where conditions are favourable for the larvæ but are unsuited for the use of petroleum.

Individual prophylaxis by the use of mosquito curtains must not be despised in the early stage of a prophylactic anti-malarial campaign, but it is clear that its value will diminish as the other measures prove effective. It has been conclusively shown that it is possible to sleep in the most malarious parts of the Campagna without infection, provided that care is taken to surround the house or the beds with mosquito nets. There are, however, certain cases where the value of mosquito curtains becomes very great.

When a boat has to pass through a malarious district or call at a malarious port, as much of the ship as possible should be screened. The use of the mosquito net is very old.

The use of quinine as a prophylactic must not be despised, especially when beginning work in a malarious country. The use of quinine to stamp out malaria was suggested by Koch. This method aims at the destruction of the parasites themselves by the general administration of quinine to all the infected persons in a locality. If this is done the Anophelines, however numerous, will be harmless, for there will be no parasites by which they can become infected. The quinine should either be given away freely or sold at a very low price. As to its value in the prevention of malaria there can be no doubt.

Many measures have been described for the prevention of malaria, and the question will arise which should be used. The answer is simple. On the whole it is best to use them all, but drainage and the filling up of ponds and pools are of much greater importance than any other measures. In any case, however, where only certain of these methods are possible, it is far better to employ those methods which can be used than to do nothing at all. It may be that it will prove impossible absolutely to exterminate mosquitoes; nevertheless, there will certainly be a great reduction in their number, and the extent of the disease will be correspondingly diminished. It must fully be understood that any one of these methods carried out thoroughly and energetically will have a very definite effect on the extent of the disease.

The measures above described will tend to remove all mosquitoes from a district, and thus they will

serve, not merely to prevent malaria, but also the many other diseases which we know are induced by the bites of mosquitoes. In time to come the importance of the prevention of such diseases will be more fully appreciated than at present. It is not unlikely that in the future we shall find that there are other diseases induced by the bites of insects in addition to those we know of already.

CHAPTER XXIV

INDUSTRIAL DISEASES

THE progress of civilisation, however beneficial it may be to the human race, is not without its disadvantages. One of the effects of the spread of civilisation has been an increase in the diseases from which mankind suffers. Of this increase there are doubtless many causes, and not the least important of these is the invention of new manufactures and occupations, which give rise to new maladies in those who follow them. If I were to include all the harmful results which may follow trades and industries the recital would prove wearisome, and therefore I will confine my account to some of the more striking.

There are only a few of the metals which commonly harm those concerned in their working, and the most important of these is lead.

LEAD POISONING

Poisoning by lead, or plumbism, is by no means confined to those who work in lead, for it may affect many others. It is a serious affection, and in the more acute form of lead poisoning the chief symptom is abdominal pain, and to this the name of "painter's colic" has been applied. The pain may be very severe, but it responds readily to suitable treatment. The other important manifestation of lead poisoning

is "wrist drop," that is, paralysis of the muscles at the back of the wrist, so that the hand falls and cannot be bent upwards. There are, however, other important morbid conditions caused by lead, and a fatal result is far from rare.

Most water pipes are composed of lead, and under certain conditions the lead in the water attacks the metal in the pipe, dissolving some of the lead, so that those who drink the water which has been conveyed through those pipes are liable to suffer from lead poisoning. The lead may also be taken into solution by the water while it has been stored in a leaden cistern. It is curious that the purer the water is—that is, the less mineral matter it contains—the greater the tendency it has to act upon lead; while if it is hard, containing much chalk and other mineral matter, the action on the lead is comparatively slight. Thus the great efforts which have been made to provide cities with pure water have led indirectly to harmful results. Even ordinary hard water is liable to act on lead pipes for a time, but before long the mineral matter present in the water combines with the lead to form some insoluble salts, which line the pipes, so that no more action can be produced.

In the year 1848 King Louis Philippe was living in exile at Claremont; and some of the members of the Orleans royal family and other persons of the household became affected with severe attacks of colic with some nervous symptoms, which were evidently the results of lead poisoning. Altogether more than a third of the residents of Claremont suffered. It was ultimately found that the attacks were due to lead in the drinking water; the lead had been taken up by the water from the leaden pipes through which

the water was supplied to the household. The quantity of lead was large, for each gallon of water contained nearly three-quarters of a grain of lead.

Sometimes lead poisoning is produced from the eating of tinned food, the acid juice of the food acting upon the solder, which contains a large proportion of lead. In some enamelled saucepans the enamel contains lead in large quantities, and if certain acid foods are cooked in these, some of the lead may go into solution. Aerated waters also occasionally contain lead, and this is sometimes due to the fact that they have been made from water already contaminated with lead, but more commonly it is due to the fact that the fittings of the syphons contain lead.

Yet another method by which lead can enter the system is the use of certain hair-dyes, for many hair-dyes contain lead, and even though the lead is merely applied externally, symptoms of lead poisoning have in certain cases been known.

Lead mining is a very old industry, for bars of lead have been found in Derbyshire bearing a stamp indicating that they were made during the Roman occupation of Britain, but the industry is not advancing, as much foreign lead is imported. In this country there is very little risk of poisoning in working in lead mines, as the ore consists of galena or lead sulphide. In Australia, however, at the mines at Broken Hill, lead miners are liable to suffer severely, and the reason for this is that there the ore is cerusite, which is the carbonate of lead, and this is more poisonous than the sulphide.

It is, however, in those who work in lead that lead poisoning has become of the greatest importance.

Those concerned in the smelting of lead are liable to be affected, for the fumes which come from the flue of the smelting-shop contain salts of lead which are poisonous. The fumes are usually carried into a flue a mile or two long, and in this long flue much of the lead is deposited, and at intervals these flues have to be cleared out, and this is a task which is very liable to lead to lead poisoning.

Those also concerned in the manufacture of white lead, which is so widely used for paint, often suffer from plumbism. White lead is made as follows: On a layer of spent tan are placed many earthenware pots containing weak acetic acid, and on the pots are placed the sheets of lead. Similar layers of tan, pots, and lead are placed over the first until the ceiling is reached, and then the door is closed and the "stacks," as they are called, are left for about three months. The tan ferments and evolves heat, and this evaporates the acetic acid, which attacks the lead, and ultimately white lead is formed. Later this has to be stripped off the unaltered metallic lead, and during this process much dust is formed, and this is very poisonous. At the present time there is less dust, as by the regulations the "beds" must be watered by a "rose." In the subsequent drying and packing there is risk of poisoning, but it is possible to replace much of the work by mechanical appliances, and these have been adopted to a very large extent. Formerly women worked in white lead factories, and plumbism was very common. Cases have occurred in which strong and healthy young women have died within three months from first entering a white lead factory. Dr. T. Oliver believes that women are more liable to plumbism than men, and that a similar predisposition

exists in certain families and in certain individuals. At present, women are forbidden by law to engage in this industry.

All who work with lead, such as file cutters, glass polishers, and plumbers, may suffer from lead poisoning.

File cutters employ a block of lead on which the file rests while it is being cut with a chisel and a hammer. The workrooms are often badly ventilated, and the dust, containing fine particles of metallic lead, is breathed by the workers.

Much of the poisoning is also due to eating without a previous washing of the hands. It is probable that in time file cutting by hand will be replaced by file cutting by machinery; this is a healthy process, and no lead is employed in it.

Glass polishers suffer from lead poisoning because putty powder is used, and this contains about 70 per cent. of oxide of lead. The putty powder is mixed with water and applied to a brush which is attached to the rim of a rapidly revolving wheel, against which the glass to be polished is held. The wheel revolves so rapidly that it sprinkles the putty powder in every direction, so that the hands and clothes of the workmen become soiled with the putty powder. Even workmen in the glass polishing shops who are not occupied in glass polishing may become affected with lead poisoning, and this is owing to the fact that the dust of the workshop contains lead and it is inhaled. Substitutes for putty powder have been suggested and employed; rouge, which is crude oxide of tin, is a decided improvement, and very good results have followed the use of metastannic acid.

Lead poisoning is perhaps most commonly seen

in painters, and in this trade it appears to be chiefly due to the painter eating with unwashed hands; for if care be taken to remove the paint from the hands before each meal, lead poisoning does not occur. It can easily be understood that the workmen's hands are smeared with particles of paint, and any food, such as bread, taken into the hands may become contaminated and serve to convey the paint to the mouth.

Type-founding is also a trade in which lead poisoning is possible. The metal used for type consists of lead to which is added a small quantity of antimony to make the metal harder and a more exact copy of the mould. Compositors also, who set up type and handle the type for several hours a day, occasionally suffer from lead poisoning. In Berlin ten per cent. of the printers were yearly affected with lead colic, but it is much less common in this country. Dr. Mortais has reported a tale told to him which illustrates well the risk of lead poisoning in printing offices. Some printers informed him that for twenty years they had tried to keep a cat in the workroom but in vain. The cat was always well fed and had plenty of milk, and for some time it would seem to be in good health, but sooner or later its eyes would lose their healthy appearance and its legs would become paralysed. This happened time after time. Lead poisoning would probably also be prevented among printers by care being paid to cleansing the hands before eating.

The earliest account which we possess of definite lead poisoning was written in 1517 by Francis Citois of Poictou. He described an endemic disease existing in that province, and even then it was recognised

that it was somehow connected with the wine of that country. We now know that preparations of lead were used to prevent the wine from turning sour. There was no intention on the part of the wine-makers to adulterate the product, for the practice was employed by every wine-grower, and was well known to all.

In Devonshire, in the eighteenth century, a similar affection was rife. It was so common, that within the five years ending in 1767 two hundred and eighty-five cases were admitted into the Devon and Exeter Hospital. It was recognised that it was somehow connected with cider, and it was noticed that it did not occur every year with equal frequency, but it was more common when cider was plentiful because of a large crop of apples. The subject was investigated by Sir George Baker, and he, by a process of clever reasoning, worked out the origin of the disease. The first step was to show that in other counties, such as Hereford, Gloucester, and Worcester, where cider was commonly drunk, those who took it did not suffer from colic. Then by analysis it was proved that Devonshire cider contained lead which was not found in cider from other counties, and therefore it was probably the cause of the disease. The question then to be solved was, How did the lead get into the cider? It was found that there were two possible sources. When cider was very plentiful all kinds of receptacles were utilised to contain the large amount of cider made, and sufficient barrels not being obtainable, recourse was had to leaden cisterns; the acid cider acted on the lead, and thus the lead was brought into solution, and gave rise to the affection. The other possible source of the lead was to be found

in the fact that leaden weights were sometimes put into the casks to prevent the cider turning sour.

In the West Indies, also, frequent attacks of colic occurred, and it was ultimately discovered that only those were affected who drank rum ; and in this case the lead made its way into the rum because the stills in which the rum was distilled were provided with leaden condensers. As soon as it was recognised that lead was the cause of the symptoms in these cases, the use of leaden condensers was done away with and the poisoning ceased.

The only ways at present in which lead poisoning occurs from the use of beverages other than water are, first, the employment of leaden shot to cleanse bottles, some of the shot being accidentally left behind, and the second is through the use of syphons in which the contained liquid comes in contact with the lead metal fittings. In this case the best preventive is the use of fittings made of pure tin.

CHAPTER XXV

INDUSTRIAL DISEASES (*continued*)

Mercurial Poisoning

Poisoning amongst workers in mercury is less common now than it was at one time, because at the present day mercury is much less used for making mirrors than formerly, and that was the chief industry in which the mercurial poisoning occurred. At the present time probably not more than 1000 persons in Great Britain are exposed to the risk of poisoning by mercury. As long ago as 1665 Dr. W. Pope referred in the *Philosophical Transactions* to tremors of the hands of a worker in cinnabar mines in Italy. Miners of mercury ores are liable to suffer, but improved care has largely reduced the risk. Formerly, when most of the mercury used in Great Britain came from Spain, the occupation of quicksilver mining was so unhealthy that the work had to be done by convicts, and the lack of personal cleanliness in the men, combined with the natural unhealthiness of the occupation, led to such a great mortality that it was recognised that the sentence of working in the quicksilver mines was almost equivalent to a sentence of death.

Mirrors used to be made with mercury, and though the process is now superseded, a description of it will be of interest. A sheet of tin-foil was spread out on a table of marble or glass, which must be perfectly level. A small amount of mercury was spread on to

this, so as to form an amalgam with it, and then a larger amount of the mercury was added and a piece of plate glass, perfectly smooth, was slid over it. Heavy weights were placed upon the face of the glass to press out the excess of the mercury, and after a few days it was found that the amalgam of tin and mercury had adhered to the glass.

This method has been replaced by the silver process, which is carried out as follows. The plate of glass is laid in a horizontal position and a solution of silver nitrate, to which has been added some ammonia, is poured over it. At first a black precipitate is formed, but later there is a deposit of shining silver. It will be seen that no mercury is used in the process.

Formerly chronic mercurial poisoning was fairly common in this country amongst water gilders, who used to employ an amalgam of gold and mercury for gilding. A layer of the amalgam was spread over the surface to be gilded, and then the article was heated by a charcoal fire, with the result that the mercury was driven off and the gold was left in a very thin layer on the surface.

The vapour of the mercury was very liable to affect the workmen engaged in the work. Fortunately the process of water-gilding has been almost completely replaced by electro-plating, to which no such risks are attached, though it is said that some buttons are still gilded by the older method ; but even water-gilding was not so dangerous an occupation as might be imagined, for a case is recorded in which a water-gilder was attacked by poisoning for the first time after having followed his occupation for seventeen years.

There are still many industries in which mercurial

poisoning may occur. The metal is used in the manufacture of barometers and thermometers. Incandescent electric lamps are often exhausted by means of a mercurial pump, and that causes risk of poisoning, and in electric meters mercury is also employed. In paint works, where anti-fouling paints are made, and in the workshops of hatters and furriers, mercurial poisoning is also possible.

When liquid metallic mercury is swallowed in even fairly large quantities, poisoning very rarely occurs, but mercurial vapour soon produces symptoms of poisoning. The main signs of mercurialism are pallor, headache, giddiness, and tremors of the tongue and limbs.

The chief ore of mercury is cinnabar or sulphide of mercury ; this has to be heated to set free the mercury, and among the men engaged in this occupation, more than ten per cent. suffered from poisoning in five years. In most of the trades dangerous from mercurialism, it is the vapour which does the harm. In the processes connected with the making of felt hats, a dilute solution of the nitrate of mercury is employed. The skin is brushed with the solution, and after drying, it is brushed by machinery to loosen the fur, and in this way the mercurial salt is scattered about.

Phosphorus Poisoning

Poisoning by phosphorus occurring in the course of industry is almost confined to the making of matches. To understand fully the problem which faces the maker of matches it is necessary to know something about phosphorus. Phosphorus exists in two very different forms, although chemically they are identical.

What is known as white phosphorus is the common form, and it is that which is used in ordinary lucifer matches. It can catch fire by simple friction, and at ordinary temperatures it is continually giving off fumes. It is extremely poisonous. In the making of matches a composition is prepared composed of phosphorus, glue, potassium chlorate, and powdered glass. It contains usually five per cent. of phosphorus. This composition is spread on a heated iron slab, and into it the matches tied up in bundles are dipped, and then they are laid out to dry. During the whole of this process phosphorus fumes are being given off, both from the composition and from the drying matches. When the matches are dry, they are placed in boxes, and the women who do this get some phosphorus on to their hands, which smell strongly of it, and if, as not rarely happens, some of the matches catch fire, dense clouds of smoke are also given off. Thus the workers inhale a great deal of phosphorus fumes.

The other form of phosphorus, or red phosphorus, as it is called, was discovered in 1845. It can be prepared cheaply from the white variety, merely by the action of heat in closed vessels. Its properties are very different from those of white phosphorus, for it will not catch fire with simple friction. Moreover, it is not poisonous, and an ounce of it has been given to animals without doing any harm, though three grains of white phosphorus have proved fatal.

Red phosphorus may be used in the manufacture of matches, but they will not strike when rubbed on a rough surface; they require to be rubbed on a specially prepared surface containing substances rich in oxygen. The best method is to make the heads of

the matches of potassium chlorate and potassium chromate, which contain much oxygen, and the red phosphorus is contained in the brownish surface on the box. These matches, therefore, contain no phosphorus of any kind; they are known as "safety matches."

The most striking result of poisoning by white phosphorus is necrosis, or death of the bone of the jaw. This condition, which is popularly known as "phossy jaw," is the direct result of the poison acting through a decayed tooth, for it seems practically certain that it does not occur if all the teeth are sound. Another peculiar effect of chronic phosphorus poisoning amongst match-makers is an increased brittleness of the limb-bones, so that they break from very slight causes; fortunately this complication is very rarely seen.

It is clear that the risks attending the manufacture of matches from white phosphorus are sufficiently great to make it necessary that the manufacture should be regulated, and the improvement of ventilation of the workroom, and careful attention to the teeth, are the most important points.

In France, where the manufacture of matches is a State monopoly, the claims for compensation by workmen suffering from necrosis of the jaw and other manifestations of phosphorus poisoning became so great, that experiments were made to discover a substitute. After several failures a compound of phosphorus, the sesquisulphide, was tried, and it has proved a success. It appears to be very little poisonous, if at all, and it is almost free from odour. It also has the merit that it will strike anywhere. The problem, therefore, of the provision of a non-poisonous

match that will strike anywhere has been solved, but it cannot quite be maintained that the solution is completely satisfactory, for French matches are far from good.

Other attempts have been made to find a non-poisonous match which will strike anywhere. The manufacture of safety matches from red phosphorus will no doubt increase, but it is not likely that they will ever replace the other form. The demand at present is for a match that will strike anywhere, and that demand will be supplied. At the beginning of 1911 it became illegal in the British Isles to employ white phosphorus in the manufacture of matches, and if this law is enforced "phossy jaw" and the other results of phosphorus poisoning should disappear.

Brassfounders' Ague

Since 1862 it has been recognised that workers in brassfoundries are very liable to have a peculiar form of disease, to which the name of "brassfounders' ague" is given. The disease affects only those who are new to the work or who return to work after an interval of two weeks or more. A few hours after the man has started work he becomes languid and feels very cold. His face is pale and covered with a cold perspiration, he shivers and his teeth chatter. He has to take to his bed, and after vomiting he is able to sleep; when he awakes, he is well. Brass consists of copper and zinc, and when brass is melted dense clouds of white smoke arise, and deposit a white powder which is oxide of zinc. The disease has nothing to do with ague, and even clinically the resemblance is only very slight. It is certainly due somehow to the brass, but there is no unanimity as to which of the two metals, copper or

zinc, is responsible for it. There is something to be said on both sides, and it is possible that the attack is due to the action of both metals.

Milk is the best preventive of brassfounders' ague, and this fact was discovered by the workmen themselves; it is useful also in the treatment of the condition.

Writers' Palsy

In 1832 Sir Charles Bell first described the affection which is now known as "writers' palsy." The disease affects most commonly those people, such as clerks, who earn their living by writing, but it is doubtful if the writing is the sole cause, because it does not always attack those who write the most. Tobacco and alcohol in excess and worry of all kinds favour its appearance. The condition is curious. There is no real lack of power, for the patient can usually paint or draw as well as before, but the muscles concerned in writing are suddenly thrown into a state of spasm as soon as any attempt is made to write. The prevention is more important than the cure. The less the movements in writing are confined to the fingers the better; the whole arm should move. Typewriting is a useful substitute, as in it entirely different muscles are employed. For the patient with writers' palsy to insist on continuing his work is very unwise, for his condition will grow worse. Telegraphists' cramp also occurs, but it is less commonly seen now than formerly, for learners are encouraged to use both hands. Early treatment is very successful; after a few months' rest, recovery always follows.

Cramp or spasm also occurs in other occupations, such as piano playing—in fact in any work in which excessive action of any muscles is required.

CHAPTER XXVI

LEGAL MEDICINE

The Recognition of Blood Stain

At many points medicine comes in contact with law.

Every citizen who is liable to serve on a jury may at any time be called upon to give a verdict in a case in which the medical evidence is the most important that is brought against the accused, and he will be in a better position to judge of the weight to be given to the evidence if he knows something of the general principles of the methods employed by medical men to elucidate the truth.

Blood Stains.—Every one thinks he is able to recognise a blood stain when he sees it, and it might be thought to be a very easy matter to say whether certain marks on clothing or furniture or weapons were or were not due to blood. Experience, however, has shown that there may be great difficulty in arriving at a certain conclusion on this matter. The more recent the blood the more easy is it to express a decided opinion, for most people would be able to speak accurately about blood marks while they are still wet, but blood undergoes changes rapidly, and its recognition soon becomes difficult. When the material on which the stain is found is white, recognition is easier than if the material is dark. A few

detached spots on a rusty knife might easily give a wrong impression. Therefore, unless the blood is very recent and is obviously blood, the evidence of those who are not specially acquainted with the subject should not be given much weight on the question whether the stains are due to blood or not.

Yet even in a recent stain it is desirable that a careful scientific examination be made, for it has happened that some dye has been mistaken for blood. When a stain is recent, the technical examination of it is fairly simple, for the blood corpuscles will not have been destroyed, and therefore it will be possible to see them and to examine them. A blood stain on any object will dissolve readily in water, and this is the first step in deciding whether the stain is blood; for many stains—rust, for instance—will not dissolve in water. The best solution to use for the purpose of dissolving the blood stain is composed of one part of glycerine to seven parts of water. When the stain is on leather, care has to be taken not to dissolve out the tannin from the leather, for that will form an insoluble compound with the blood-colouring matter, and this is also true of oak or any other wood containing tannin. A little of the stain is dissolved and then it is examined under the microscope, and the blood corpuscles can be seen, and it is possible, sometimes, to give an opinion as to the group of animals from which the blood has come. I will deal more fully with this question a little later, when I discuss whether it is possible to distinguish human blood from that of the lower animals.

The discovery of the red corpuscles proves with absolute certainty that the liquid which produced the stain was blood. When the stain is a little older the

red corpuscles will have disappeared. They have become destroyed by the drying, but they have left behind them their colouring matter, and it is by this colouring matter that it is possible to recognise whether the stains are the stains of blood. As the blood stains get older they soon lose their reddish colour, and become darker and browner in tint, until they may be almost black. When they are on iron or steel weapons or objects they are very likely to be mixed with rust marks, and then it becomes still more difficult to distinguish them from rust. It is possible to separate the blood from the rust by means of the water and glycerine solution already mentioned, for the blood will dissolve, while the rust will not, and filtration will give a clear solution of the blood.

The colouring matter of blood as it exists in the body, and for a short time after it has been shed, is called hæmoglobin, and this can be obtained in a crystalline form which is characteristic, so that the crystals will prove that the liquid causing the stain was blood. The stain must be very recent in order that it shall be possible for hæmoglobin crystals to be obtained from it. Much more commonly, when the time has come for an examination of a stain which may be blood, it is so old that it is no longer possible to obtain the crystals of hæmoglobin, for it has broken up. It is in these circumstances necessary to employ another chemical test. By the addition of a little acetic acid and a minute quantity of sodium chloride or common salt and the application of heat some minute crystals will be formed. Their colour may vary from a faint yellowish red to a dark brownish black; and they are of a definite shape, and they are technically described as oblique rhombic prisms.

These crystals are crystals of "hæmin," and they can be readily identified under the microscope. A further test corroborating the opinion that these are crystals of hæmin can be applied by adding a minute drop of hydrogen peroxide, and immediately small bubbles of gas will be given off from each crystal. The hæmin test is perfectly conclusive of the presence of blood, and it is applicable to a blood stain however old it may be.

Day's test may also be applied. This is to be performed as follows: A drop or two of tincture of guaiacum is added to the solution of the stain, and then a few drops of ozonic ether are poured on to the top of the liquid, and a blue colour will soon appear where the two liquids touch. This is an extremely delicate test, for there is no coloured substance other than hæmoglobin or substances derived from it which will give this reaction.

Perhaps the most striking proof of the presence of blood is afforded by the spectroscope. It will be necessary to give a short account of this instrument. When light is allowed to pass through a prism, it is broken up into its constituent colours, and we have, in place of the white light, a series of tints passing from red at one end through yellow and blue to violet at the other end of the spectrum. When sunlight is the light employed it is seen at once that many small dark bands pass across the spectrum, and it is found that in sunlight these dark bands are always in the same relative positions, and we know that they correspond to certain chemical substances, and their presence in sunlight proves to us that these chemical substances exist in the sun. For instance, in the yellow part of the spectrum is a very definite dark

band which proves the presence of sodium in the sun. These dark bands are useful in examining any spectrum, for they enable us to distinguish between two spectra which are very much alike. When we examine with a spectroscope any coloured liquid we find that every liquid has its own spectrum. When we examine blood we find a very definite spectrum, but it has several forms according to the condition of the colouring matter. Thus, if hæmoglobin is present, and the blood is red as it is in the arteries of the body, a spectrum would be formed containing two broad dark bands just to the right of the sodium line; if then we add a substance by which the oxygen is taken away, a single band replaces the other two. By readmitting oxygen to the blood the two bands reappear, and this transformation of the two bands into the single band and of the single band into the two bands can be repeated indefinitely. If the blood stain is older the spectroscopic test is differently applied, but the results are equally conclusive.

There are certain substances which to some extent give spectra resembling those of blood, but they react differently to chemical substances, and there is no difficulty in distinguishing between them. The spectra of alkanet root and of madder in some respects bear a close resemblance to those of blood, but there is no difficulty in distinguishing between their spectra.

The spectroscopic test is very trustworthy and very delicate, for it is said to be capable of detecting $\frac{1}{1000}$ of a grain of hæmoglobin, though if the amount of blood stain is very small, the test has to be applied with the aid of a microscope.

As each of these three tests, the hæmin crystal

test, the guaiacum test, and the spectroscopic test, is trustworthy in itself, it is obvious that if all three tests give a definite result there cannot be the very faintest doubt that the stain is the stain of blood.

Supposing that the stain has been examined by all the tests that I have mentioned, or at least those which are applicable to the particular stain, and it has been decided with certainty that the stain has been produced by blood, the question then arises, Is it possible to speak with any certainty as to the source of the blood? The question practically only concerns the blood of vertebrate animals, and of these there are five main groups. First there are the mammals to which man belongs, secondly there is the class of birds, thirdly the class of reptiles, fourthly amphibians, and fifthly fish. Now, the red corpuscles of these separate classes do differ in certain respects one from another.

The mammalia possess red corpuscles which are round, and concave on each side; and they possess no nucleus. Curiously, the members of the camel tribe are the only mammals which have oval red corpuscles, but they resemble other mammals in having no nucleus. In birds the red corpuscles are oval and bi-convex and they possess a nucleus: and the red corpuscles of reptiles and amphibians are also oval and are provided with a nucleus. In fish the corpuscles are round and nucleated. Thus, if the blood were sufficiently recent to show the red corpuscles, it would be possible to say whether the blood was the blood of a mammal or not, and this microscopic test has been applied with success in the following case.

A man maintained that he had coughed up some

blood, but when the blood was examined microscopically it was at once seen that the red corpuscles in it were oval and nucleated, and therefore it could not be mammalian blood; and later he acknowledged that the blood was obtained from a fowl.

Sometimes the mere size of the corpuscle is sufficient to decide that the blood is not mammalian, for on the whole the amphibians have corpuscles which are much larger than those of mammalia. The frog's corpuscle is nearly three times as long as a human red corpuscle, and in one amphibian, the Amphiuma, the corpuscle is eleven times as long as a human red corpuscle, that is to say, it is about $\frac{1}{300}$ of an inch in length, and it is visible to the naked eye.

We see, then, that it is possible, if the corpuscles of the blood can be obtained for examination, to decide whether those corpuscles belong to mammalian blood or not.

The further question then arises: Supposing that we have identified the blood as derived from a mammalian animal, can we take a step further and say that the blood is certainly human?

The mammalian blood corpuscles differ in size. The largest appear to be those of the elephant, which measure about $\frac{1}{2700}$ of an inch, while the smallest are those of the musk deer, $\frac{1}{12000}$ of an inch. The human red corpuscle measures $\frac{1}{3200}$ of an inch, but the size of the corpuscle does not appear to depend on the size of the animal, though the elephant happens to be one of the largest mammals and the musk deer is a small mammal. But the red corpuscle of a mouse is three times as big as that of the musk deer, though the mouse is a much smaller animal. In animals belonging to the same group, the size of the

red corpuscle does vary somewhat with the size of the animal. On the whole it may be said that all the animals whose blood is likely to be confused with human blood, such as the horse, the ox, and the sheep, have red corpuscles which are smaller than those of man.

Therefore if the corpuscles in a specimen of blood when examined were found to be definitely smaller than human red corpuscles the examiner would be justified in saying that in all probability the corpuscles were not human, but I do not think he would be justified in going further than this. For, though attempts have been made to establish the size of the corpuscles as a decisive test as to the nature of the source of the blood, the differences are so minute that it would not be fair to an accused person to let his fate be decided on this point.

From time to time it has been suggested to utilise for the discrimination of the blood of one animal from another the fact that the crystals of hæmoglobin do vary according to their source. The fact of the difference in the shapes of the crystals cannot be denied, and in certain cases the differences are so striking that a decision might confidently be based upon them. On the other hand, in certain cases the differences are extremely minute, and may depend on slight differences in the form of the crystals and the angle which one side makes with another. In the present stage of our knowledge at least, these differences must not be allowed to have much weight.

Within the last few years it has been suggested to utilise "hæmolysis" in the detection of the source of a specimen of blood. The method is a little complicated, but it may be stated briefly as follows :—

If into the body of an animal, say of a rabbit, some

human blood is injected, and after a short time a little of the blood of the rabbit is mixed with human blood, it is found to have the power of destroying the human red corpuscles; they break up, and the liquid becomes transparent. This is "hæmolysis." Thus if the blood of a rabbit which has been altered by human blood were mixed with a little unknown blood and it was found that the red corpuscles of the unknown blood were destroyed, there would be great probability that the unknown blood was human. The results, when the test has been applied experimentally, seem fairly trustworthy, but the subject is still entirely in an experimental stage, and therefore no great reliance can be placed on it, but it is possible that it may become of value in medico-legal matters in the future.

To sum up; first it is possible to detect blood and blood stains however old they may be, though the more recent they are the more easy a decision becomes. Secondly, we can recognise the difference between mammalian blood and the blood of the lower animals provided that the blood has been shed sufficiently recently to enable the corpuscles to be examined. Thirdly, it is not possible to identify with certainty the source of blood; we cannot definitely say it is human, although from measurement of the red blood corpuscles and by other means we may form a fairly decided opinion as to their origin.

CHAPTER XXVII

LEGAL MEDICINE (*continued*)

Poisoning

I HAVE in the chapter on diseases of occupation dealt with a number of cases in which poisoning occurs in trades, and there I have also described a few instances in which it resulted from accident, but here I wish to speak especially of cases of poisoning not connected with occupation. Every now and then cases are tried in the law courts in which a person is accused of having given poison with intent to harm, and the decision will often turn on the medical evidence, and the members of the jury should be able to appreciate the nature of the medical evidence and to utilise it in arriving at a verdict.

In the past there can be little doubt that charges of poisoning were made too frequently. Whenever death occurred suddenly without external violence, the most natural explanation appeared to be that it was due to the action of some poison administered with malicious intent. The rapid deaths which sometimes occur in appendicitis or in perforated gastric ulcer may well have seemed to be the effect of poisoning at a time when the knowledge of medicine was much less than it is at present.

Death may also occur with startling suddenness when it is caused by apoplexy or by disease of the

heart, and if for any reason suspicion had fallen on any one, the rapidity of the death would be held to be a fact confirming the suspicion. When it was considered right to administer torture to get evidence, it was not difficult to obtain confessions as to the guilt of the suspected man, even though he was innocent. Even at the present day amongst savage races a sudden death is always regarded as the result of poisoning or witchcraft, and some one has to suffer for it.

It is certain that many have been executed for murders which had not been committed. This should make us careful not to be too ready to suspect poison, but on the other hand, it is very necessary that every sudden death, every obscure death, should be adequately investigated; for many cases, even within recent years, have shown us that in deaths by poisoning no suspicion may arise for some time until some other circumstance may arouse it.

Once suspicion has been aroused it is no difficult matter to detect a poison. There is a popular idea that some poisons cannot be detected, and therefore those poisons are chosen by would-be murderers. This idea is wholly mistaken, for it can be said with certainty that every poison known to us can be detected by one means or another. This is true, not merely of an examination soon after death, but it is also true for nearly all poisons, even when months have elapsed, or even when the body has lain in the grave for years.

The resources of chemistry and physiology are so great, that we have at our disposal means of identification which were absolutely unknown fifty years ago. The rarer alkaloids, such as aconitine, have been

within recent years employed for homicidal purposes, but these substances can be identified with as much certainty as the commoner poisons, such as arsenic and antimony.

In the Middle Ages poisoning was perhaps common, but even then deaths were ascribed to poison which were really due to natural causes. It is said that at one time poisoning was very commonly practised, especially in Italy, but much that was reported of the methods employed was absurd. Readers of Dumas' *Monte Cristo* may remember the description given by the Count of the method of preparation of a poison. A cabbage was watered with a solution of a poison, and three days later it was given to a rabbit which died shortly after; a chicken fed on the body of the rabbit and it died also. In this manner it was suggested that the poisons of the Borgias were made, and it was thought that they could not be detected after death. That may have been true at that time, but it is certain that at present they could be recognised. There can be no doubt that there has been much exaggeration as to the abstruse methods that used to be adopted.

It is very difficult to give an exact answer to the question, "What is a poison?" The best definition appears to be, "A poison is anything which is capable of destroying life by chemical action on the tissues or by physiological action after absorption." This may be a little too wide, but at least it includes all the substances which are used for homicidal purposes.

With regard to the sale of poisons, the law in England at present is hardly sufficiently strict. Schedules of poisons have been drawn up, and the poisons enumerated in them can only be sold with

certain restrictions. The package must bear a label on which is the name of the poison and also the word "poison." The most virulent of the poisons can only be sold to persons known to the seller or introduced to him by some one known to him, and the sale must be entered in a book kept for the purpose. These regulations apply even to "vermin killers," and if fully carried out they would do much to prevent both intentional and accidental poisoning. Until recently crude carbolic acid was often sold in unlabelled bottles, and some parish authorities were even in the habit of giving it away for disinfecting purposes; but, as the recipient provided the bottle, the carbolic acid was generally put into an ordinary wine or beer bottle, and it was often unlabelled. Cases of poisoning did arise from this cause.

By the present law poisons intended for external use must be dispensed in special bottles, which can be recognised by the touch as different from ordinary medicine bottles. Much ingenuity has been expended in devising bottles which cannot be mistaken. Triangular bottles have been employed, and one or more of the surfaces have been roughened, so that the mere feel will at once indicate that it is not an ordinary bottle. One very ingenious form invented could only stand on the end at which was the cork, so that it was impossible to pour it out by mistake, but I do not think it came into use.

Most of the accidental poisonings arise because people take up a bottle in the dark and pour out some of its contents into a glass and drink without seeing what they are taking. This should never be done, however certain one may be of the identity of the bottle. Some one else may have displaced the

bottle, and another may be in its place. Experience shows that many deaths are caused in this way. A man has been in the habit of taking some medicine frequently from a bottle always kept in the same place, and some day he picks up a bottle from that place and takes a dose from it, and not until he finds that it burns his mouth does he have the slightest suspicion that he has taken it from the wrong bottle. Sometimes, if these substances happen to be tasteless, the mistake may not be noticed until severe or even fatal symptoms come on. Among the poorer classes substances like spirits of salts (hydrochloric acid) or oil of vitriol (sulphuric acid) are often kept in wine or beer bottles. A child, seeing the bottle, will think that it contains beer, and will try to drink some, and, from fear of detection, he will drink a mouthful or more hurriedly, and, before he has time to notice the burning taste of the liquid, he has swallowed it. Many deaths occur in this way, and one great preventive would be to take care that these dangerous substances are never kept in beer bottles, and they should not be put where children can reach them.

The Mode of Action of Poisons

Poisons do harm, either by their local action or by their action after they have been absorbed into the blood stream. The local action is seen in the effect of the strong acids and alkalies, such as sulphuric acid and caustic potash. These have a caustic effect on the tissues they touch; if they are strong they destroy the tissues completely; if they are weaker, they excite severe inflammation. The mouth usually is burnt, and the effect is also seen in

the gullet and the stomach. Sometimes it is possible to recognise which of these poisons has been employed; for instance, if the skin of the lips is turned yellow, nitric acid must have been used. Most often poisons exert their special action after they have been absorbed into the blood and have been carried about the body by the circulation. Thus, if opium be given, it has no action until it has entered the blood-vessels and been carried to the brain, which it affects with its special action. In a similar way, strychnine has no action until, after absorption, it has been carried to the spinal cord, where it irritates the nerve cells and causes the spasms which are the characteristic effect of strychnine.

Antidotes

An antidote is any substance which will counteract a poison. These are of several kinds, and they act in different ways. Some act *mechanically*, such as white of egg, olive oil, and demulcent fluids; water also by diluting the poison will act in the same way, and similarly alcohol counteracts the effects of carbolic acid. Some of these, such as white of egg, also act chemically; as, for instance, where white of egg is given in a case of poisoning by corrosive sublimate, it acts partly mechanically by protecting the wall of the stomach from the action of the irritant poison, and partly chemically by combining with the corrosive sublimate. It is related that Michael Faraday, when lecturing at the Royal Institution, had on his lecture table a glass of water and also a glass containing a solution of corrosive sublimate. By an accident he drank some of the poisonous solution, but he

immediately perceived his mistake because of the burning taste of the liquid. At once he took a solution of white of egg, which was fortunately at hand, and so he escaped any harm from the accident. The quantity he had taken was sufficient to prove fatal.

Some antidotes act *chemically;* that is to say, they neutralise the poison. If an acid has been taken, alkalies may be able to neutralise it, but it is obvious that the antidote must not be too strong, or it will itself do harm. Even plaster from the wall or ceiling has been used with success in cases of poisoning by acids, especially oxalic acid. Similarly, weak acids, such as vinegar, have been employed to neutralise caustic alkalies.

The third way in which antidotes act is *physiologically*. Thus one alkaloid is injected to neutralise the effects of another alkaloid. Physiological antidotes which work well in the laboratory do not always give equally satisfactory results when tried in cases of poisoning.

When poisoning was, or at least was supposed to be, more common than it is at present attempts were made to devise a universal antidote against all poisons. Several of them were invented, and the most famous of these was "orvietan," which was made by Girolamo Ferrante of Orvieto, in Italy; it was also called "Venice treacle," and it is mentioned in Scott's *Kenilworth.*

When poison is taken, there are many circumstances which may modify its action. The quantity is, of course, the main factor determining the result; and the greater the quantity the more severe are the symptoms. This is true of almost all poisons, but

when the poison is an emetic a small dose may be more dangerous than a large one, for the small dose will be retained while the larger dose will be vomited and the patient may recover. The more soluble a poison is, the more quickly it acts; while, in the solid condition, its action is delayed. Habitual indulgence in a poison will in many cases give a partial immunity. Every one knows that this is true of tobacco and alcohol. Opium also has a similar effect, and doses can be taken after prolonged indulgence which would certainly kill a person unaccustomed to the drug. Children and infants, even though they are very easily affected by opium, may become habituated to it. Grainger reported that in the factory districts it was the custom to drug the children with laudanum; the drugging began soon after birth, and ultimately a child might be taking as much as fifteen or twenty drops of laudanum.

Arsenic also appears capable of conferring on those who take it habitually an immunity against itself. Long ago it was reported that in Styria the peasants habitually take arsenic in quantities sufficient to poison any one else. Much doubt has been thrown on the correctness of these statements, and I am not satisfied that they are true.

When a poison is administered immediately after a meal, its action manifests itself more slowly, and it is generally less violent than if it is given when the stomach is empty.

In all cases of poisoning it must be borne in mind that idiosyncrasies to various substances are not rarely present. The possibility of the existence of an idiosyncrasy must always be remembered when symptoms of poisoning appear to arise from an

ordinary medicinal dose. I have dealt more fully with this matter in chapter xxviii.

The onset of symptoms in a case of poisoning is generally sudden, occurring in a person previously perfectly well. It is often immediately after a meal or a dose of medicine. This occurs both in cases of acute and chronic poisoning; and in chronic cases the coincidences are sometimes sufficiently striking to attract notice; for instance, pain and vomiting may come on soon after any food or drink has been taken. In nearly all cases of poisoning the symptoms do not exactly correspond to any disease; or the general condition of the patient is out of relation to the symptoms of which he complains.

When symptoms of violent irritant poisoning arise after a meal, and especially when more than one person suffers from them, there is always the possibility that the cause is some decomposition product in the food and not what we ordinarily call poisons. In some of these cases in which the food has been "tinned," the toxic symptoms may be due to some of the metal forming the tin or the solder with which the tin was sealed. The chief metals proving dangerous in this way are tin and lead, and the symptoms are those resulting from poisoning by these metals. Quite apart, however, from the poisons of metallic origin it is certain that food sometimes, whether tinned or not, may give rise to serious symptoms closely resembling poisoning.

When meat disagrees it is nearly always after it has been prepared in certain ways. "German sausage" may give rise to toxic symptoms, and especially if it is eaten raw or imperfectly cooked. These symptoms appear to be due mainly to a special bacillus, the

Bacillus botulinus. At Welbeck seventy-two persons were attacked after eating cold boiled ham, and four of the number died. In this case a bacillus was found, and it was probably responsible for the attacks.

Veal pies have given rise to many cases of poisoning. In 1898, at Oldham, fifty-two persons were attacked after eating veal pies, and of these four died. In such cases the cause is probably a bacillus.

On Good Friday 1882, at Inverness, over a hundred persons were taken ill after eating "hot cross buns," and when an inquiry was made into the outbreak, it was concluded that the cause was an irritant alkaloid probably derived from the spice used in making the buns.

Honey, even when it is not adulterated, may sometimes give rise to symptoms of poisoning. This is nearly always due to the fact that the bees have fed on poisonous flowers. It will be remembered that the ten thousand Greeks under Xenophon, when returning through Asia Minor, were attacked with some troublesome symptoms after eating honey. I have referred to this occurrence in the chapter on idiosyncrasies.

Most epidemics due to milk are caused by the typhoid or diphtheria bacillus, but other attacks more of the nature of poisoning do occur. In 1899, at a school treat, sixty persons were attacked with severe symptoms of irritant poisoning, and the only food taken had been cake and milk; fortunately no fatal cases appeared. In 1901, in Glasgow, six hundred persons were attacked with symptoms of irritant poisoning, and the investigation proved that the attack was due to the milk of one dairy, and it was found that a cow, the milk of which was used on the day

of the outbreak, had died shortly after milking time. From cheese, ice cream, and milk a definite chemical poison has been isolated; it is called "tyrotoxicon," and it appears to be a product of the action of the butyric acid bacillus; it produces symptoms of irritation.

All forms of fish may cause toxic symptoms, especially if the fish is not perfectly fresh. From tinned fish, such as salmon, similar symptoms may occur, and death may sometimes follow. Lobsters, crabs, and shellfish, especially mussels, may also give rise to serious manifestations. The symptoms are generally those of an irritant, and a nettle-rash may be produced. When the mussels have been scraped off a vessel, they seem especially harmful, and then may give rise to narcotic symptoms. A man who ate a large quantity of mussels scraped from the side of a vessel became absolutely unconscious, with very slow breathing, and he died some ten hours later.

In many of the cases of illness from food, the cause is a micro-organism, but still there are many in which no microbe can be found; in most of these there are discovered on analysis chemical substances to which the names of "ptomaines" or "cadaveric alkaloids" have been given. They resemble very closely the alkaloids found in plants, both chemically and physiologically. Many of these ptomaines are formed by decomposition, and are produced by the action of bacteria. Some other chemical substances of simpler composition are also found, and these are probably also poisonous. The conclusions to be drawn from the many cases which have been recorded of illness and death following the eating of "tinned" food are, that if "tinned" foods are eaten,

only foods of good brands should be selected ; that any "blown" tins (that is to say, tins which are distended at each end from the formation of gas in the interior) should be destroyed ; that no tainted meat should ever be eaten ; and that all meat, whatever its source, should be well cooked. If these precautions were taken, the number of cases of poisoning from food would be much diminished.

Closely allied to cases of poisoning are those instances in which irritant plants, such as the *Primula obconica*, give rise to irritation of the skin ; some animals also, such as the woolly caterpillars, and jellyfish, may give rise to very troublesome symptoms.

The bites and stings of insects may cause much irritation. A wasp sting on the tongue has proved fatal from the swelling to which it gives rise causing suffocation. A single wasp sting has proved fatal within fifteen minutes to a lady twenty-three years old ; death in this case was probably due to shock ; and another similar case has also been recorded. Bee-stings are sometimes productive of serious symptoms, but they are rarely fatal, though when a man has been stung by hundreds of bees death has resulted.

Snake-bites in this country rarely case death, and even serious symptoms from the bite of the viper are not common. When they do occur it is generally in the summer, for then the venom is more powerful. Children suffer more than adults, because the dose is larger in proportion to the size of the body.

It will not be necessary for me even to mention all the substances which have been or might be poisonous. It will suffice if I refer briefly to a few of the more important substances.

The mineral acids, sulphuric, nitric, and hydro-

chloric acid, are much used for cleaning metals, both in trades and in domestic use, and therefore cases of accidental poisoning are not at all rare. The main method of prevention would be the exercise of care in the bottles in which the acids are kept, as mentioned above. Carbolic acid is so widely used for disinfecting purposes that cases of poisoning by it are not uncommon; fortunately it is now put in Schedule 2 of poisons. At present about ten per cent. of the deaths from poisons are due to carbolic acid.

Borax and boracic acid are used so very extensively for preserving foods and milk, that is a matter of the greatest importance to consider what is the degree of toxicity of these two substances. No case appears ever to have been recorded in which death resulted from the internal use of borax or boracic acid in doses such as are customary for the preservation of food, or even in bigger doses; so that no serious harm is likely to follow its use as a food preservative, if the quantity employed is really moderate. A danger, however, arises from the fact that when a perishable article of food, such as milk, passes through many hands, each person will in turn be inclined to add some food preservative, and thus the total amount contained may easily be such as to cause illness. While it is difficult to forbid entirely the use of borax and boracic acid, it seems to be desirable that the law should fix a limit to the percentage that should be present.

Copper cooking vessels are probably not so common nowadays as they were at one time, and therefore copper poisoning is not now so common as it was. If the contents of a copper saucepan contain common salt or vinegar, or any acid substance such as rhubarb, or if any oily or fatty material be present, some of the

copper may get dissolved and may cause symptoms of poisoning. No such substances as these should therefore ever be cooked in copper vessels. All copper vessels should be tinned, and care should be taken that the tin is not worn away. A case has been recorded in which several members of a family ate rhubarb which had been cooked in a copper saucepan; it had been tinned but the tinning had been in parts worn away, and moreover the saucepan had not been well cleaned. They were all taken ill, and one died.

In another way the possibility of poisoning by copper arises. It has long been customary to colour peas and other vegetables by means of copper salts, and some old cookery books advise that a penny should be placed in the saucepan, as it will improve the colour of vegetables; or that they should be stirred with a copper spoon. The copper is added usually in the form of blue vitriol (copper sulphate), but it forms a green compound with the organic acids of the vegetables. It is probable that the quantity of copper used is so small that the amount taken at a single meal cannot do harm, but it is not unlikely that repeated doses of even a small amount might be injurious. It is very desirable that the coppering of preserved vegetables should be made illegal.

The potato-blight is sometimes prevented by spraying the plants with a solution of bluestone. I know of no evidence that the potatoes are ever affected, or contain any of the poison, but one fatal case has been recorded in which a farm labourer employed in spraying the potatoes was poisoned, apparently by eating without washing his hands.

Compounds of arsenic are used for several purposes, for washing sheep, for killing weeds, for fly-

papers, and for colouring wall papers. Eight members of a family were poisoned by arsenic by taking water for drinking purposes from a pail which had contained a sheep-dip. Four of the family died. By law arsenic, when sold in small quantities, must be mixed with soot or indigo, but there is little doubt that this regulation is often evaded. Poisoning by arsenic may certainly be caused by living in rooms the walls of which are papered with wall-paper containing arsenic. Although green papers are popularly supposed to be specially dangerous, papers of many tints may contain the poison. For a long time the manner in which the arsenic of the wall paper reached the occupiers of the room was unknown; it was thought to be by dust. It has, however, been shown that several minute fungi live in the wall paper, and possess the power of decomposing the salts of arsenic, forming a gaseous compound, which is given off into the air of the room and then taken in with the breath by those living in the room.

Many ores contain a small percentage of arsenic, and so it happens that a small quantity exists in many substances. Sulphuric acid frequently contains a little arsenic, and if this impure acid is used to make glucose, the product will contain some arsenic also. Glucose is much used in modern methods of manufacturing beer, and as a result beer may contain arsenic. This was the source by which the arsenic gained access to the beer which gave rise in 1900 to the extensive Manchester epidemic of arsenical poisoning, in which at least 6000 people were affected. As glucose is also employed for making confectionery, and as an adulterant of honey, arsenic may find its way into the body in many ways.

Poisoning by carbonic acid gas is not very common. It is the carbonic acid in the "choke-damp" which kills coal miners after an explosion. When men go down wells, or into brewers' vats to clean them out, and are rendered unconscious, the cause is carbonic acid. Limekilns also give off much of the gas, which may cause unconsciousness and death.

It has generally been thought that the air of a well or vat is safe for breathing, if a candle will continue to burn in it. This has been shown not to be true by the following case. A girl carrying a candle entered a cellar in which grape juice was fermenting; she was seized with giddiness and dropped the candle on to the floor, but she was able to run out of the cellar, and close the door; then she fell unconscious on to the ground. When the door was opened the candle was found burning in the cellar.

Carbonic oxide is a poisonous gas that must not be confused with carbonic acid. This gas is formed whenever organic matter is burned with an insufficient supply of air. The poisonous character of coal gas is largely due to the presence of carbonic oxide, and this is the reason why water gas is very poisonous, for it contains much of it.

Even one per cent. of carbonic oxide gas in the air proves rapidly fatal to those breathing it. When death occurs from a leaking stove the death is due mainly to carbonic oxide, and closed anthracite or coke stoves should never be employed in bedrooms. Some cases have been recorded of death from the products of combustion of coke or charcoal, where there was no fire in the room. In one of these cases the fumes came from a stove burning charcoal in the

room above; the fumes passed through an iron pipe into a flue, and then descended into the fireplace of the bed-room below, and there proved fatal.

I do not intend to discuss the question whether alcohol is of value or not as an article of diet, but that it can act as a poison is beyond dispute. With the symptoms of ordinary drunkenness I need not deal. Acute alcoholic poisoning results from a very large dose of alcohol in a concentrated form, brandy or some other spirit commonly being the cause. A boy six years old died from three ounces of whisky; a woman forty-one years of age died within six hours of drinking a pint and a half of whisky; and a pint of spirit has proved fatal to a man in eight hours.

Prussic acid is a very powerful poison; it is sometimes given intentionally. It is contained in the essential oil of bitter almonds, which is used to flavour confectionery, and which may contain a large percentage of prussic acid.

Formerly the oil of bitter almonds proved fatal in a number of cases every year, but it is now a scheduled poison, and therefore it is not so easily obtained. Almond flavour is a weak solution of the oil. Prussic acid is contained in the kernels of cherries, and to a minute extent in the pips of apples and pears.

In a trial where the prisoner was accused of killing by prussic acid, the defence was raised that the prussic acid found in the stomach was derived from the pips of some apples recently eaten. The defence failed. Nitrobenzene is an artificial product; it has an odour resembling bitter almonds, and is used in perfumes and for flavouring pastry. It is very poisonous, for fifteen drops have proved fatal. A peculiar bluish appearance of the skin may be present,

and a similar result follows poisoning by aniline, which has gained entrance by being used in the manufacture of the shoes worn.

There are many British plants which may prove fatal, especially to children, and the laburnum, the monkshood, the deadly nightshade, and toadstools deserve special mention. Children in elementary schools in the country might well be taught to recognise the common poisonous plants of the district.

Belladonna and aconite are common constituents of liniments, and they are liable to be taken in mistake for medicines. Opium and its alkaloid morphine cause many deaths every year. Many patent medicines contain opium, especially those intended for the relief of coughs and pain; it is also a constituent of some soothing syrups for children, and this is especially dangerous, because children do not stand opium well, and even one drop of laudanum has proved fatal when given to an infant seven days old. It is worthy of discussion whether any patent medicine intended for the use of children should be allowed to contain opium.

CHAPTER XXVIII

IDIOSYNCRASIES

THE old proverb that "One man's food is another man's poison" is based on a very large measure of truth. Substances which are perfectly harmless to one person, or even to the majority of the members of the human race, may produce dire results on a few people, and similar differences exist between different groups of animals. The nux vomica bean, which contains the very powerful poison strychnine, capable of killing all the higher animals, is liable to be attacked by a beetle which can feed on it, not only with impunity but even with benefit. An extract of belladonna, or the deadly nightshade, which contains the virulent poison atropine, is often devoured by a minute mite which flourishes on this strange food. Goats are said to be able to eat the leaves of the aconite plant, which proves so poisonous to man and most animals, and yet to suffer no harm. From these instances (and many other similar cases could be quoted) we see that there are peculiarities in various groups of animals which render them immune to special poisons. Still more common, however, than this strange immunity is a tendency which is seen in individual members of groups of animals to differ from their fellows when brought into contact with some special substances.

Our knowledge of these individual peculiarities is

much more extensive with regard to members of the human race than with regard to any other class of animal. The instances are by no means rare. We often hear some one say that he cannot take quinine or some other drug because it produces an effect on him other than that which is produced on most people. It is possible that to some small extent imagination has a share in the production of these untoward results, but this will suffice to explain only a very few cases. Sea-sickness, for instance, is produced in nearly every one when journeying on a rough sea for the first time, and some never lose their susceptibility, but there are a few fortunate individuals who have never been upset in the slightest degree when at sea, however rough it may have been. This sensitiveness to the movement of a boat varies greatly in different people, and there is little doubt that the expectation of being sea-sick has no small share in the result. Every one has known of people who have suffered from sea-sickness even while the steamer was still on the smooth waters of a river. In such a case nothing but the expectation of sea-sickness could be responsible for the result. Many children and some adults suffer from train-sickness.

Idiosyncrasies exist in regard both to medicine and to food. As a rule nearly all drugs are fairly uniform in their action, and if any drug gives rise frequently to unexpected results, it may be taken as almost certain that that drug varies in composition. Yet even with drugs which are uniform in chemical nature, variations of the effects may certainly occur. Most of the powerful drugs have been found at one time or another to affect excessively persons who have been treated with them, and it is remarkable

how great is the regularity with which in these persons the harmful effects follow even small doses of the substance. It is said that opium, which in most people produces a sedative, quieting effect, has been known to give rise to convulsions similar to those which would follow the administration of an excessive dose of strychnine, and many of these cases are so carefully recorded that we can have no doubt that they are true. Quinine, when given in small doses, usually causes few symptoms—perhaps there may be a slight headache—but sometimes it causes eruptions of various kinds. Belladonna may occasionally, even when merely applied externally in the form of a plaster, give rise to symptoms of mental disturbance. Potassium bromide, when given to most people, causes no change in the skin, but it may, even in moderate doses, give rise to several very striking forms of skin eruptions; and this is true also of potassium iodide. These anomalous effects produced by drugs are certainly remarkable, but still more striking are those analogous disturbances which are caused by certain articles of food. It is indeed strange that there is hardly any form of food used which has not at some time or another given rise to harmful symptoms. I am not speaking here of effects due to decomposition having taken place in the food by the growth of a micro-organism which may have produced some poisonous substance, but to the effect arising from the taking of food in a good and satisfactory condition. When food has undergone decomposition it affects, as a rule, all who partake of it, though even here we find differences not to be accounted for by the varying quantities of food which have been taken. When the harmful symptoms are due to the

peculiarity of the person who partakes of the food, we find that others can eat of it without suffering any ill effects. Especially remarkable is the fact of the uniformity with which the effects are produced in the same person. Not long ago, a boy about fourteen years old said that he was unable to take oatmeal porridge as it made his face swell. A little natural scepticism was felt as to the truth of his statement, and the boy was persuaded to eat some porridge under observation. Before the meal was finished, the skin of the boy's face was seen to begin to swell, and within twenty minutes of the commencement of the meal the face was so swollen that he was unable to see out of one eye. Many persons complain of feeling discomfort after eating porridge ; irritation of the skin not unfrequently occurs, but I am not aware of any other case in which such marked results followed as in the case of the boy I have mentioned. It is especially remarkable in these cases of food poisoning, that the harmful effects are seen even when the susceptible person is not aware that he has had that special kind of food.

Rice is a substance which has on many occasions been known to produce harmful effects ; it must not be forgotten that rice is especially prone to decomposition, and many consider that beri-beri is somehow associated with decomposed rice. But I am not referring to such cases as these ; there are people who suffer after having eaten rice even in very small quantities. In one case shortness of breath always followed the taking of rice, even in the smallest quantities. A lady who suffered in this way complained one day of severe breathlessness after taking some soup, and she said that she felt sure she had had

some rice. It was found on investigation that the soup had been thickened with a little rice flour. In another case in which rice always gave rise to attacks of shortness of breath the sufferer was especially careful to avoid any article of food which was likely to contain rice. One day he had a severe attack of shortness of breath after drinking some bottled beer, but for some time he could not discover how any rice could have got into the beer. At last he discovered that, as the beer had become flat, some grains of rice had been introduced in order to excite fresh fermentation.

Honey is especially liable to cause unexpected symptoms. This is no doubt due in part to the presence of some unusual constituent obtained from some poisonous plant. Readers of Xenophon's *Anabasis* will remember the description of the severe attacks of illness from which the "Ten Thousand" suffered after eating honey in the Colchian Hills. It has been suggested that the honey of this district owed its peculiar properties to the fact that the bees had fed on a species of rhododendron (Ponticus). The curious flavour of Australian honey is said to be due to the eucalyptus tree. It is, however, unlikely that the serious symptoms which occurred in the following case can be ascribed to any unusual constituent. A man found that whenever he took honey he always suffered from swelling of the tongue, frothing of the mouth, and blueness of the fingers, and these symptoms followed whatever the source of the honey, though it was noticed that they were more severe when the honey was eaten in the comb. It has long been known and widely recognised that fish are specially prone to produce harmful symptoms, and these are

seen more particularly with some fish than with others. The mackerel is very likely to give rise to serious symptoms, and in most cases this is associated with decomposition changes. Still, sufficient cases have been recorded which seem to show that individual peculiarities exist in some persons which render them specially liable to be affected by this article of food.

We have seen above that the quantity of the special article of food required to cause severe symptoms may be in some cases extremely small, but it is almost impossible to estimate how very minute the quantity needed may be. Eggs have a very harmful effect on many people, and sometimes merely the quantity necessary for glazing a roll or a bun has been sufficient to evoke severe symptoms. In most of these cases of egg-poisoning the sufferers complain of soreness of the throat, and abdominal pain and vomiting. Even the external application of the white of egg may irritate the skin. There is some evidence that with care some of the patients with these peculiarities can be cured, by accustoming them at first to very minute doses of the poisonous substance; but the evidence of cure is up to the present not very strong.

Even more remarkable instances of idiosyncrasy have been recorded. Sir Kenelm Digby has related that if a rose were laid on the cheek of a certain lady while she was asleep the cheek was blistered, and "rose cold" is, if not so common as hay fever, at least as troublesome when it occurs. Hay fever, too, attacks only a small percentage of those exposed to the cause, which certainly appears to be the pollen of the hay. Cases have been recorded where the

sight or smell of pork was sufficient to cause faintness. As Shakespeare said, "Some men there are, love not a gaping pig; some that are mad, if they behold a cat." We have no clue to such idiosyncrasies as these. They are not merely the result of imagination, for the exciting cause generally acts perfectly well even when its presence is unknown to the sufferer. That idiosyncrasies of all kinds exist, there can be no doubt, and as soon as recognised they have to be taken into account both in diagnosis and in treatment.

CHAPTER XXIX

TREATMENT BY X-RAYS, BY RADIUM, AND BY FINSEN LIGHT

I HAVE described in the chapter on Instruments for Diagnosis the general arrangement of the apparatus needed for the production of X-rays, and it will be unnecessary to repeat here the account, for in all essentials the apparatus employed is the same.

Very soon after the publication by Röntgen of his discovery it was found that the X-rays were capable of affecting the skin and other tissues of those who were exposed to them; and these harmful effects I will speak more about after I have described the beneficial effects of treatment with the rays.

When it was seen that the X-rays were powerful enough to lead to the destruction of healthy tissues, it was thought probable that they might be able to exert a similar influence on diseased tissue, therefore the rays were soon tried in various diseased conditions.

It took a long time before those employing X-rays became capable of utilising them to the greatest extent, for it was difficult to determine the correct amount. Many attempts were made to measure the rays, and at first these attempts depended on the strength of the primary current and the size of the spark gap, or even the strength of the secondary circuit; but all these proved to be fallacious tests. Sabouraud was the first to introduce accuracy into

the matter, for he showed how the X-rays might be measured with a fair amount of accuracy. His method consisted in exposing to the rays a "pastille," composed of a cyanide of barium and potassium. This substance undergoes a definite change of tint after exposure to a certain quantity of the rays, and when the colour of the pastille has attained a certain standard tint, the required amount has been attained; in fact the method employed is that adopted by photographers for measuring the amount of exposure that should be given to a photographic plate.

Whatever amount of X-rays be administered, there is always an interval between the exposure to the rays and the first appearance of symptoms, and this is called the "latent period." The latent period may be as short as a week; this is only in cases in which a large dose of the rays has been given; or the latent period may be as long as three weeks, when a small dose of the rays has been administered. In each case that dose of the rays is chosen which experience has shown to be the most suitable for producing the effects desired.

Many diseases have been treated by means of the X-rays, but at present those which seem to be the best suited for this method of treatment are not very numerous. They are chiefly affections of the skin. Lupus responds very well to the action of the X-rays, and as a large area can be treated at one time this treatment is especially suitable for those extensive cases which under the Finsen light would require a very long treatment, for by the Finsen light only a very small area can be treated at one time. The results after X-rays for lupus are not always so good in appearance as after the Finsen light.

Treatment by X-rays

There is a very superficial form of cancer which is known as rodent ulcer; it usually occurs on the face, and it is very suitable for treatment by the X-rays; the results are generally very good.

In the last few years, the X-rays have been employed with great success in the treatment of ringworm of the head. With ordinary methods of treatment ringworm of the scalp is usually a very intractable disease even though great care be taken, while if the treatment is carried out carelessly by the patient or his friends, as is only too commonly the case among the poorer classes, it may last for several years. The main difficulty in the treatment is due to the fact that the microbe which is the cause of the disease invades the little pocket, or "hair follicle," in which the hair lies, and we know of no way in which antiseptics can be made to pass down to the germs so as to kill them. It was found by Sabouraud of Paris that when the X-rays are applied to the scalp in the correct dose, the hair will after two or three weeks fall out completely, and with the hairs will come out all the germs causing the disease, so that the hair follicles are left free from the germs. By this method it must be distinctly understood that the X-rays do not act as an antiseptic, for it is doubtful if they have any antiseptic action, but the rays merely serve to remove completely the hairs from their follicles, and in this way, too, all the germs are removed. The correct dose is measured by means of a Sabouraud's "pastille." The hair falls out in about three weeks, and after a few weeks more the new hairs begin to appear, and these new hairs are free from germs. With care no harm results, and the duration of the disease is very much shortened. At the Ringworm School of the

A Safety Cabinet for X-ray Operators

The frequent use of X-rays may be attended with the gravest danger to the operator, but this is eliminated by placing the patient in a special cabinet lined with lead and iron. The windows are of lead glass, which is impervious to the rays. The rays are controlled from the outside. The child is being treated for ringworm.

Metropolitan Asylums Board the cure of a case of ringworm of the scalp before the introduction of the X-ray treatment used to take on an average one year and nine months. Since the X-ray treatment has been employed the average duration of the stay of a child in the schools has been reduced to about four months.

A determined effort is now being made by the London School Authority to extirpate ringworm from London, and it may well be that in a few years the disease may become rare.

The question often arises whether any danger is likely to result from the use of X-rays in treatment. When the rays had been only recently introduced they were used without any precautions, for their harmful effects were not known, and a few patients suffered from them, but much more often the sufferer was the operator, for he was exposed, not only on one or two or a few occasions to the rays but for hundreds of times, and unfortunately several of the operators have died as the result of the injuries caused by the rays. Now, however, precautions are regularly taken, and the operator is careful not to expose himself to the direct course of the rays, and he wears gloves which will not allow the rays to pass through to his hands. From our present knowledge of the rays it can confidently be asserted that no harm will result to a patient from the rays during the exposure necessary for examination of a part by means of the screen or for the taking of the skiagram, and with treatment also no harm will follow if the ordinary precautions are observed.

It has been suggested that using the X-rays for the cure of ringworm may lead to lack of develop-

ment of the tender brains of young children. In answer to this it may be said that we have no evidence supporting this view—in fact all the evidence points in the opposite direction; and Sabouraud, who has now had seven years' experience of his method, is able to state definitely that children thus treated are as intelligent as other children who have not been submitted to the influence of the rays.

In conclusion it may be said that the X-rays form a powerful weapon, capable of doing much good when employed with care, capable also of doing harm if used carelessly: but this may equally be said of many other methods employed in medicine and surgery, and it is quite certain that with due care the X-rays will bring nothing but good.

Radium

Not long after Röntgen's discovery of the rays which are called by his name, Becquerel, while investigating some salts of uranium, found that they gave out rays which were able to produce feeble photographic effects, even after passing through bodies opaque to light. Compounds of thorium were found to possess similar properties. At first it was thought that the power was connected with the uranium itself, for the metal was more active than any of its compounds; but further investigation showed that some minerals containing uranium, especially pitch-blende and chalcolite, were more active even than uranium itself, and from these minerals radium was separated by Mme. Curie by a prolonged research in which the constituents of pitch-blende were tested separately. Other radio-active metals have been recognised, but

radium remains the best known and the most used of them all.

The cost of radium is very great, and there are two reasons for this: one is that the minerals containing it are not very widely distributed, and the second reason is that even in those minerals in which it exists to the greatest extent it is present in only a very minute percentage. The mine from which the first supplies of pitch-blende were obtained is situated at Joachimstal near Carlsbad, but mines occur in this country in Cornwall, and the demand for radium has resulted in attempts being made to work pitch-blende in several other parts of the world.

Radium is allied chemically to barium and thorium, and its amount in any ore bears a constant ratio to the amount of uranium present; that is, the amount of radium is about one-millionth part of the amount of uranium. A ton of the pitch-blende from the mine at Joachimstal will yield about two grains and a half of radium.

Radium is always giving off heat, so that its temperature is always two or three degrees Fahrenheit above that of the surrounding air; and an idea of the amount of heat given off may be gathered from the statement that it is sufficient every hour to melt its own weight of ice.

Radium is continuously giving off an "emanation," and also it sends out "rays." The "emanation" is a gas, which is luminous; it can be condensed to a liquid by means of cold; and it possesses the power of making "radio-active" any objects in its neighbourhood. The "emanation" is continuously giving off a large quantity of heat. The "rays" are of several kinds, and they have been named Alpha, Beta, and

Gamma rays. They all possess the power of acting on photographic plates, like X-rays, and they can make substances like barium cyanide become phosphorescent.

The Alpha rays consist of minute particles charged with positive electricity, travelling at a speed of some twenty thousand miles a second. They can pass through opaque objects to a certain extent, but it does not take much to stop them; a plate of aluminium only one-five-hundredth part of an inch in thickness is sufficient to block them completely.

The Beta rays are composed of particles negatively electrified; they are very much smaller than the Alpha rays, probably only one-thousandth part of the size, but they travel fifty times as fast. They have much more penetrating power, somewhere about a hundred times as much, for they can pass through a plate of aluminium one-fifth of an inch thick.

The Gamma rays are not electrified, and they travel at a velocity equal to that of light. They can pass through a plate of aluminium twenty inches thick. It appears that the Gamma rays are identical with, or at least indistinguishable from, the Röntgen rays.

As radium is continuously emitting the emanation and these rays it is continuously losing weight, so that ultimately a piece of radium bromide would disappear, but the rate of disintegration is extremely slow, and it has been calculated that the life of a portion of radium is some 1200 years or more.

Inasmuch as radium is continuously being broken up, one of two conclusions must follow. Either there was formerly a very much larger quantity of radium in the world than at present, or radium is continuously being formed. It seems now certain that radium is,

on the one hand, being formed continuously, and on the other it is continuously breaking up ; and there is reason to think that uranium is the substance which, by undergoing a change, gives rise to radium.

The Applications of Radium in Medicine

It was early recognised that radium was capable by means of the rays it emitted of producing effects similar to those obtained by the use of the Röntgen apparatus, but the first indication that the rays of radium were capable of affecting the human body was afforded by an unintentional experiment performed by Curie. He travelled for some hours having a fairly large amount of radium in a tube in his pocket, and a few weeks later he discovered a sore on his side opposite the place where the tube of radium had been. It took, however, some little time for him to recognise the connection between the two facts. When it was seen that radium could affect healthy skin very much in the same way as Röntgen rays, its action was tried on various diseased conditions of which I shall speak later.

Experience has shown that the Alpha rays have very small penetrating power, for they are hardly able to pass through the skin, but they are liable to cause much irritation. The Beta rays can pass through a greater thickness of tissue, but the Gamma rays, which are probably identical with X-rays, have the greatest penetrative powers. The proportions of the rays vary greatly, and it has been estimated that unscreened radium, *i.e.* radium not surrounded by any metal screen, gives off 90 per cent. of Alpha rays, 9 per cent. of Beta rays, and only 1 per cent. of

Gamma rays. When surrounded by a thin metal screen the proportions will be greatly altered, so that barely 1 per cent. of Alpha rays, 90 per cent. of Beta rays, and 9 per cent. of Gamma rays will be emitted; while if a lead screen is used all the Alpha rays will be blocked, and only 10 per cent. of the Beta rays and 90 per cent. of Gamma rays will pass through. Therefore by using metallic plates of greater or less thickness it is possible to "filter the rays," so as to obtain those which are specially desired.

Radium can cause inflammation of the skin or even ulceration if the application is sufficiently prolonged. If tadpoles are exposed to the influence of radium, they cease to grow, and seeds when exposed will cease to sprout, but radium has very little power over bacteria.

The duration of the application of radium will necessarily vary with the strength of the preparation; and the screen usually used with it will differ according to the action required. If a superficial effect is desired, then the radium may be used unscreened, but if it is wished to eliminate the superficial action, screens must be introduced, sufficient to block out the Alpha rays and part of the Beta rays. As to the use of radium in treatment, it may be said that in the first place various superficial conditions of the skin yield to radium, such as birth-marks or "port-wine stains" and hairy or pigmented moles. Chronic eczema and overgrown scars also are amenable to treatment with radium. Further, some of the more superficial forms of cancer, such as "rodent ulcer," can be cured by radium, and even in the more deeply seated forms of cancer, good is sometimes

done, but it is too early yet to speak with any certainty on this point. Sometimes neuralgia has yielded to treatment with radium.

It has been said that good has resulted from the injection of the radium "emanation" in a case of cancer in a mouse, but I am not aware that any such success has been met with in malignant disease in the human being. It is worthy of note that many natural mineral waters, such as those of Bath, contain radio-active substances, and it is possible that some of the beneficial effects produced by these waters may be due to their radio-activity.

Finsen Light

That rays of light can affect beneficially the health of the body has been known for ages. Improvement in the general health follows life in the open air, and this is in some part at least attributable to the effect of the light of the sun. The bleached and unhealthy appearance of plants which have been grown in the dark is an exemplification of the importance of light. In the chapter on Germs I have referred to the fact that the rays of the sun have a very definitely harmful effect on most forms of microbes that cause disease, and in this way also light is beneficial. It was not, however, until comparatively recently that the light of the sun was put to any therapeutic use.

Finsen of Copenhagen employed the rays of the sun for the treatment of lupus; the patients were placed in the open air and the rays of the sun were concentrated on the affected spot by means of a large lens, while the interposition of a glass "trough"

containing a special liquid served to exclude the greater part of the heat rays. The results were very good. The patches healed rapidly, and the scar was smooth and unnoticeable. The light of the sun, however, is in most climates only occasionally available, and the ultra-violet or actinic rays on which the remedial effect depends are present in a very small proportion during the winter months. Finsen therefore decided to try the effects of a very strong electric arc lamp. The light of the arc lamp contains many actinic rays, and it must be sharply distinguished from the ordinary incandescent electric lamp which is used in private houses, for the light of the latter contains hardly any actinic rays : so that the incandescent lamp is useless for the purpose of treatment.

The light from the arc lamp is conducted to the part to be treated and concentrated on it by means of quartz lenses, for quartz does not obstruct the actinic rays to the same extent as glass. Further, if the maximum effect is desired, it is necessary to compress the part with a quartz lens in order to empty the blood-vessels of the blood, and when the part is thus rendered free from blòod, the rays can penetrate more deeply. To obviate the heating effects the piece of quartz used to compress the parts is often made double, and a current of water is allowed to circulate in the space between them.

The Finsen lamp is very effective in most cases of lupus, and it is especially valuable in the more superficial forms. Unfortunately it is not possible to treat a large area at one time ; a patch of skin about the size of a shilling is all that can be treated at once, and as each area requires from five to twenty ex-

TREATMENT BY RADIUM

There may be a great future for radium; at present its use is mainly restricted to various skin conditions, such as birth-marks, and superficial cancers. The radium is simply applied to the part by means of a small holder for a short time. Radium is one of the most costly substances known, and only a small quantity is employed; but it is not used up in any way, and so it lasts indefinitely.

posures, and each of these lasts some twenty minutes, it is clear that Finsen treatment is somewhat slow; but so far as the appearance and results are concerned, it cannot be surpassed.

The Finsen lamp is a very large and expensive instrument, and many smaller arc lamps have been constructed, which give satisfactory results, though in some cases the duration of exposure needs to be increased.

There are a few other skin diseases in which light treatment appears to be of value, but it is especially useful for lupus, and when used in this disease the results are all that can be desired.

Carbonic Acid Snow

It is convenient to describe the use of solid carbonic acid here, though it is not allied to the radiant forms of treatment.

While the cautery has been in use for many centuries as a remedial agent, it is only within the last few years that high degrees of cold have been employed in the treatment of disease. Repeatedly freezing a part by means of ethyl chloride spray has given good results in some cases of lupus, but it has never been widely adopted, and the effect is slow because the degree of cold is not great. Solid carbonic acid, or "carbonic acid snow," as it is often called, is a very convenient method of applying intense cold. To put the matter simply, it may be said that the temperature of solid carbonic acid is just as much below the temperature of ice as the temperature of ice is below that of boiling water. The "snow" is very easily obtained. In all large

towns carbonic acid gas is used for making effervescent mineral waters, and for this purpose it can be bought compressed in strong steel cylinders. The pressure in these cylinders is so great that the gas is condensed to a liquid. When the tap of a cylinder is turned and the gas is allowed to escape slowly, it comes out as gas, but if the gas is allowed to escape rapidly it absorbs heat so quickly in becoming gaseous, that part of it is converted into the solid form, looking very much like snow. This can be collected and formed by compression into a rod about the size of a lead pencil, and with this rod of solid carbonic acid snow diseased tissues can be treated.

When the pencil is pressed on the affected part it is rapidly frozen; sometimes the application lasts only five or ten seconds, sometimes it may last a minute, and the effect produced depends in part on the duration of the application and in part on the amount of pressure exerted. When the pencil is removed the part remains hard and white for a few seconds and then it thaws. The application of the pencil causes very little pain, but as it thaws it hurts a little and for a few days afterwards it may be sore. If the application has been slight, very little effect may follow; with a stronger application the superficial tissues are destroyed, and if necessary even deeper effects may be produced. The cases most suited for this treatment are nævi, warts, lupus, rodent ulcer, and "port-wine marks."

This method is at present new, and sufficient time has not yet elapsed to fix with any exactness the class of cases most suitable for treatment. One point, however, deserves special mention. The appearance of the skin after treatment is extremely good; the scar

is so soft and supple that it is hardly distinguishable from healthy skin.

An even greater degree of cold than that produced by solid carbonic acid is available, and that is afforded by liquid air. It produces its effect much more rapidly, and it gives very satisfactory results, but it is not, as yet, a commercial substance, and therefore it is only used to a very small extent.

CHAPTER XXX

MALINGERING

FROM time to time persons are found who endeavour to deceive others by imitating the signs of disease, and this fraud is called malingering. It has existed from very early times, and it has always been difficult to detect. In Shakespeare's play, the *Second Part of Henry VI.*, the Duke of Gloster detects the fraud of Simcox, who claimed to have been cured of blindness by visiting the shrine of St. Alban. Gloster showed that Simcox had never been blind by asking him the colour of various objects, and in every case he named the colours correctly, which could not be possible if he had been cured only immediately before. Then Gloster convicts Simcox of fraud in simulating lameness, for when he is asked how he became lame he says that it was from climbing into a tree for plums when he was a youth ; this was hardly possible if he had been born blind. Further, the lameness disappears rapidly after one stroke from the whip of the beadle. Malingering is as common as ever at the present time, and much care and skill are required to detect it ; but the increase of our knowledge enables us to recognise it in cases which at one time would have been considered genuine.

There are many motives which impel persons to simulate the manifestations of disease. To beggars who can appear to possess diseases likely to excite

the sympathy of the passer-by, the rewards of proficiency may be very great. Every one will remember Sir Conan Doyle's story of *The Man with the Twisted Lip*, in which is told the tale of a man who, when at home, led a life of respectability, but he became, during his working hours, a professional beggar in the City of London, with a curious malformation of his lip. Whether this individual's tale was founded on fact or not, it is certain that a great many professional beggars earn comfortable livelihoods by putting on the signs of disease. Paralysis is one of the most money-bringing maladies, for the passer-by, feeling the difference between his own strength and power of walking and the pitiable condition of the paralysed beggar, gives readily; and if the site has been wisely chosen, the pecuniary results may be very much more than would be expected.

Internal pains, however much the supposed sufferer groans, do not prove so remunerative as some form of disease that is visible to others, and it is very fatiguing to groan for long so that all who pass by may hear. If a person in the street is supposed to be suffering from acute pains, those who see him are more ready to take him to the hospital than to give him money, but that would hardly suit the professional beggar. I have been told that in the East End of London it is possible to buy pieces of adhesive plaster on which have been painted sores of various kinds. One of these is placed on the body or limb of the poor sufferer, so as just to be visible to the kind-hearted. It says much for the good-heartedness of the British public that a large number of healthy people reap the reward of their deceit and live comfortably on it.

Fits also pay well. They are generally epileptiform in character, and if an epileptic fit comes on in some public place, it has time to pass off before the patient is taken to a hospital, and many coins find their way into the patient's hand. Fits as a rule are, however, overdone, and it is true generally that most malingerers are inclined to overdo the symptoms. They either have too many symptoms or they have them in such a very severe form that if the symptoms were genuine the patients would soon die. Some beggars who have had opportunities of observing fits or other forms of disease for months or years become very expert, and may for a short time deceive even medical men, but their success is always short-lived if they are submitted to a careful medical examination. The frothing at the mouth, which is a well-known sign of an epileptic fit, is generally managed by the aid of a piece of soap concealed in the mouth, but the unconsciousness which is absolute in real epilepsy cannot stand, in these imitation fits, the infliction of a sharp pain.

Malingering is frequently seen in countries where military service is compulsory, the object of the malingerers being to render themselves ineligible for service, but even in countries where voluntary service exists many who enlist endeavour to obtain their discharge by simulating an attack of some malady.

Sometimes these unwilling soldiers have inflicted real injuries on themselves in order to escape service, and although this can hardly be called malingering it is very closely allied to it. At one time it was necessary for the soldier, before he could load his musket, to bite off the end of the cartridge. In those days it was not uncommon for a man to have one or more teeth extracted or filed down so as to obtain

exemption, or if he had already entered the service he would have "an accident," and one of his front teeth would be knocked out, so that he was no longer able to bite off the end of the cartridge. Sometimes also the trigger finger has been chopped off with the same intention. There is a tale which is told of a very determined attempt to escape service. A soldier became suddenly attacked with paralysis of the right arm. No cause could be found for it and the paralysis appeared to be complete, and even when he was awakened suddenly in the middle of the night, still the arm did not move. All the efforts of those surgeons who examined him were expended in vain to prove him to be a malingerer. For malingering was suspected, but no proof could be obtained. Ultimately, after several months of examination spent in vain, he was given his discharge, and he left the town on the top of a stage coach. Many of his comrades had come to see him off, and as the coach drove away he waved a last farewell with his paralysed arm.

Once a man simulated blindness. He was carefully examined, but nothing wrong was to be seen in his eyes even after the most careful examination, and though the doctors were practically certain the man was a malingerer, they could not prove it. At last they thought they would have a decisive test; he was placed near the edge of a pier and told to walk straight forward. He took several steps and then fell into the water, for he knew well that those responsible for the test could not let him drown. Later, when he had obtained his discharge, his eyesight wonderfully returned to him. Another man with paralysis of one arm was able to use both arms

in swimming as soon as he was thrown into the water. A very interesting case, known some years ago to many connected with hospitals in London, was a man who had a true paralysis of the left arm, and weakness of the left leg, the result of a former attack of apoplexy. He had been in hospital, where he had been very comfortable, and as the paralysis of his arm prevented him doing any work, he was always much more happy in the hospital than out of it. Therefore, whenever he wished to be received into a hospital, it was his habit to go to an inn near the hospital of his choice. After he had been there a little while he would suddenly fall down apparently unconscious, and he would be carried into the receiving room of the hospital. The medical officer who received him would immediately recognise the paralysis of one side, and from the age of the patient he would diagnose some form of apoplexy and would receive him into a ward. After a few weeks some of the paralysis would pass off, but the arm would not regain its power. Then, when all the improvement had occurred that seemed likely, he would be sent to a convalescent home. There are many general hospitals in London, and he visited most of these in turn, and each visit gave him about three months' rest. Unfortunately for him, however, though the number of hospitals in London is large, it is not unlimited, and therefore after a few years he was compelled to return to a hospital he had already visited, and on more than one occasion he was recognised by some one who had known him before.

It is always possible to detect malingering if the examination be sufficiently prolonged. Often the symptoms are not consistent with any known disease, and they may vary from day to day in a way which

does not occur in a real disease. A very useful method is to mention in the hearing of the patient that he has not some symptoms that he ought to have; for instance, a physician may say that the hand should be more curved than it is, and in all probability, when the patient is next seen, the hand will be more curved than it was before. The use of an anæsthetic solves many difficult problems, and will sometimes enable a definite opinion to be expressed in a case of malingering.

It is very easy in many ways for a malingerer to produce eruptions and sores on the skin by rubbing or applying acids. A very common method is to dip a penny in vinegar and to bind it firmly on the arm. If this is done daily for a few days a very definite ulcer will result. Matches dipped in water and rubbed on the skin will also produce sore places, but all these attempts are easily detected by those accustomed to skin diseases.

Compensation for injuries is a prolific source of simulation. When a railway accident occurs, it is not very rare for some one who has not been hurt at all, or has received only a slight injury, to pretend that he has received internal injuries sufficiently severe to prevent him working. In railway accidents such injuries certainly do occur, though no outside signs of injury are present, for sometimes patients who have been suspected of malingering have died as the result of their injuries; but it is equally certain that many of those who bring claims against the railway companies are malingering. The present method of paying a sum down for cases where there is no visible proof of injury certainly favours malingering, for some of these cases have recovered rapidly soon after the money has been paid. Doubtless

occasionally this recovery has been assisted by the relief from worry which adequate compensation would give to a genuine sufferer, but in many cases the recovery occurs because there was no disease before. In all cases of real doubt the fairest method both to the company and to the patient seems to be for the court to order an annual payment so long as the disability shall continue.

Colour blindness is sometimes simulated; but it is easy to detect, for most of the attempts are made by men who have vague ideas as to the nature of the condition. There are tints which appear almost identical to ordinary eyes, but to colour-blind eyes they are very different. Another method that is employed is to put over the malingerer's eyes spectacles containing tinted glasses.

In this and many other cases the great widening of modern medical knowledge renders it possible to detect fraud that would have passed unscathed through all the tests in the past.

Sometimes it has happened that the attempt to imitatedisease has been only too successful, and permanent serious injury, and even death itself, has followed. Many years ago a man started an ulcer in his leg by means of a copper coin soaked in vinegar. His general health was not good, and the inflammation he had started spread rapidly. Gangrene of the leg followed, and amputation had to be performed. It is marvellous what trouble malingerers will take to accomplish their ends, and though it is probable that in a small proportion of these cases there is some mental aberration, it is certain that in the vast majority of malingerers personal gain is the sole motive of the deception.

CHAPTER XXXI

THE MEDICINE OF THE FUTURE

In the preceding pages I have given a brief account of what medicine was in the past, and I have also described to some extent the medicine of the present day. I have mentioned some of the difficulties which have been encountered in the progress of medicine, and I have told how some of those difficulties have been overcome; how year by year and century by century advances have been made. At some epochs the advances have been great and striking, but far more commonly progress has been made by small and almost imperceptible steps, and only those who have looked at the practice of medicine with a broad view have been able to recognise the progress that has occurred. For many years the authority of the ancient masters of medicine tended to retard the advance of the science; respect for those who had done so much for medicine tended to restrain their successors from deviating too widely or too suddenly from what had been taught so long before. But in spite of this, and in spite of the then want of knowledge of anatomy and physiology, medicine and surgery steadily made their way onward. From time to time they may have strayed into by-paths which led nowhere, but this was never for long. The innate love of truth, the desire to find the best methods of treatment and the true origin

of disease, have always dominated the medical mind.

Within the last century the progress has been phenomenal; more advance has been made during that period of time than in many centuries preceding it, and more progress still will be made in the future than in the past or present. They of the past have done much; the present has done still more; but we look forward with hope and confidence to the future to solve many problems and to remove many difficulties which trouble us at present. Only those who know truly how much has been done in the past and can be done in the present can appreciate fully what the future has in store for us. By considering the weather of past years, by studying the laws of meteorology, it is possible for us to foretell, to a certain extent, the weather that is to come. So, too, with medicine. When we look upon what our predecessors have done with their scanty knowledge of those sciences, anatomy and physiology, on which true medicine must rest, when we regard what is being done at the present day with our very thorough study of all the sciences ancillary to medicine, we may have good hope for the future. With a much fuller knowledge of anatomy and physiology than we possess even now, with a wider appreciation of the truths of animal chemistry, with a more thorough knowledge of the ways and powers of the many micro-organisms which attack the human body, we may feel sure that in the future the science of medicine will rise to heights almost incomprehensible to us of to-day. We can be certain that in the future our difficulties will be cleared away, our hardest problems will be solved.

At one time those who were working for the ad-

vance of medicine were few in number; now, however, the spread of civilisation has added greatly to the fighting forces of medical science. In the past the spread of Greek learning to the Arabs did much to advance medicine; so in the present day the spread of knowledge to many parts of the world has added largely to the number of those who are studying to promote the progress of the science of healing. Not only the countries of Europe, but Canada and the United States of America and the countries of South America, are producing men who are earnestly devoting themselves to the task of adding to our knowledge of the remedial art, and those sciences on which it depends. In our own time to the list of civilised and scientific nations has been added Japan. So that to-day in many parts of the world medical science is being cultivated to an extent never known before. To every country medicine has been indebted. In England we find Harvey discovering the circulation of the blood; to America we owe the discovery of surgical anæsthesia; to Koch of Berlin we are indebted for the discovery of the bacillus of tuberculosis; to Pasteur of France for the germ theory of fermentation; to Lister in Scotland we owe antiseptic surgery; to Kitasato of Japan we are indebted for the discovery of the bacillus of plague. Each country furnishes its quota for the fighting force. The scientific men of all nations are as one in their furtherance of science and truth; science knows no political boundaries, and the sincere follower of science is, so far as his science is concerned, a true cosmopolitan.

What, then, of the medicine and surgery that are to come? In the first place we shall know far more

than we do at present of the causation of disease. We shall learn that there are factors in the production of morbid conditions which are unknown to us at present, and that there are modes of action, even of forces now well known to us, of which we do not dream. It would be useless to enumerate the many unsolved mysteries as to the mode of origin of disease. The history of past progress in medicine has only too often told us how far from the truth have been our guesses as to the way in which diseases arise.

In the chapter on Malaria I have described the results of the observations of careful physicians before the true etiology of that disease was discovered, and from our present superior knowledge we can see how far from the truth were their guesses, and on what erroneous lines their surmises proceeded. So will it be with the causes of those diseases as yet unknown to us. When those who come after us learn the true etiology they will feel inclined to smile at the guesses and theories we are now propounding. When the truth is learned much that appears incomprehensible to us will become perfectly clear, and apparent inconsistencies will be explained.

To take only one instance. At the present time we have no certain knowledge of the cause of cancer. Theories there are many, but facts there are few, and certainty there is none. With an increased knowledge of the causes of this disease will doubtless come an increased power of treatment, and this scourge will in due time be removed from us.

Will new diseases arise? It is difficult to be sure that new microbic diseases will appear, but the chances are greatly in favour of it. At all events it is certain that diseases hitherto unknown will be

described, as occurs at present. It may be that some diseases have not been recognised as separate diseases previously, and they may have been confused with some other more common affection; but be the explanation what it may, we may feel quite certain that in the future, as in the past, new maladies will receive recognition.

Certainly in the class of diseases due to occupations new diseases must arise, for new conditions will exist, and will give rise to new affections. In the chapter on the Diseases of Occupations I have already referred to "caisson disease," which occurs in workmen who labour in the highly compressed air in caissons in the beds of rivers. This is an entirely new disease, and it could not arise until the conditions causing it were present, and it is only within the last few years that men have had to work under a great increase of atmospheric pressure. In deep mines there is some increase of pressure of the air, but that is nothing compared to the increase met with in some caisson work. So in the future new conditions will arise. So also the electric injuries, occurring only too commonly nowadays, are new to medical science. The very increase in our knowledge of nature will add to the diseases from which man will suffer. The burns caused by the X-rays and by radium could not occur until the advance of science had put in our hands the powers that X-rays and radium possess. The very luxuries due to the increase of civilisation add also to the number of diseases. The evils resulting from alcohol and tobacco could not be known until alcohol and tobacco were employed.

In these latter days perhaps the greatest evil resulting from an ever-increasing civilisation depends

on the growth of drug habits. In place of the opium and Indian hemp which sufficed our predecessors, we have now in this last century a long list of drugs from morphia to cocaine, and from cocaine to chloral, and it is but too certain that in the time to come the advance of chemical knowledge will add numerous drugs to the list. It may well be that some may think that the benefits accruing from the science of medicine are dearly bought at the price of an increase in the means of producing disease, but with this opinion I cannot agree. The fault lies not with the science which produces these drugs, for every one of them has a beneficial use, but with the men who misuse them and put to a harmful purpose that which was meant to help the human race. Those, however, who have the most belief in the beneficent function of medical science look forward not so much to a time when all the ills that flesh is heir to can be remedied by the skill of the physician, but to a time when the science of medicine will have advanced so far as to be able to prevent the occurrence of these maladies. It is a noble aim to strive to cure our suffering brethren, to put an end to the pain which has arisen sometimes through faults of their own, sometimes through the action of others, and sometimes through the laws of Nature which they have disobeyed. Yet it is far greater to strive to prevent these diseases before they appear, and that is the rôle of the medicine of the future. The study of hygiene or preventive medicine has made great advances. By an accurate appreciation of the causes giving rise to disease it is now possible to prevent many maladies which were at one time looked upon as inevitable or as the result of the wrath of the gods.

The Medicine of the Future

With the greater knowledge of the causes of disease which time will bring us, there will be put into the hands of the physician of the future a weapon far more powerful than any we can wield to-day. We may reasonably look forward to the time when many of the evils which afflict us now will be avoidable, and as a result the span of the life of man, which even in our own time has extended beyond what it was a hundred years ago, will be stretched several decades beyond the three score years and ten that at one time were allotted to man. Yet, to attain such results as these there will be stringent conditions. On the willingness of the individual to accept the teachings of the science of those days, to obey the dictates of the medicine of the future, will depend the reward which science will then offer.

Even in those far-off days there will be some who prefer the gratification of the moment to the health of the future ; who disregard the teachings of science because they do not apply to the immediate present. To such as these Nature will still reply as she replies to-day to those who break her laws, whether unwittingly or of malice aforethought, that they shall surely die. To these medicine can only offer what is second best—not the prevention of disease, but its treatment, more or less efficacious as the breach of the laws of Nature has been less or more pronounced.

Printed by Ballantyne, Hanson & Co.
Edinburgh & London

INDEX

Abdomen, surgery of the, 170
Æsculapius, 25
Agar agar, 65
Alcoholic poisoning, 283
Alternation of generations, 216
Amœba, 84
Anæsthesia, discovery of, 123
,, ,, local, 133
,, ,, spinal, 134
Anæsthetics, 123
Anglo-Saxon medicine, 26
Ankylostoma, 38
Ankylostomiasis, 38
Anopheles, 220
Anophelines, 234
Anthrax, 80
Antibodies, 88
Antidotes, 272
Antiseptic surgery, 136
Antitoxin serum for diphtheria, 92
Antivenom serum, 90
Appendicitis, 170
Aretæus, 91
Arnott, J., 134
Arsenic, 274
Arsenic poisoning, 280
Aseptic surgery, 149
Auenbrugger, 109
Auscultation, 110

Bacillus of anthrax, 41
,, of diphtheria, 92
,, of influenza, 41, 76
,, of tetanus, 94
Bacteriology, 63
Baker, Sir George, 249
Beddoes, Dr., 125
Bell, Sir Charles, 257
Bleeders, 60
Blood, coagulation time of, 61
,, corpuscles, counting, 59
,, crystals, 265
,, stains, 258
Bones, wiring, 175
Braid, James, 126
Brain, the surgery of the, 167
Brassfounder's ague, 256

Cadaveric alkaloids, 277
Caisson disease, 32
Calf vaccine, 105
Calmette, 90
Canal, fresh water, 236
,, Panama, 238
Cancer, 165
Carbolic acid, 144
Carbonic acid poisoning, 282
,, acid snow, 303
,, oxide poisoning, 282
Catgut for ligatures, 155
Causes of disease, 29
Celsus, 190, 210
Chemical causes of disease, 36
Chemicals, effect on germs, 50
Chicken cholera, 80
Cinchona bark, 202
Citois, Francis, 248
Coagulation time of blood, 61
Cocaine, 134
Cold as a cause of disease, 34
Cold, effect on germs, 45
Collier, R. H., 127
Colton, Dr. G. Q., 127
Compositors, 247
Compound microscope, 56
Copaic Plain, 207
Copper poisoning, 279
Corpuscles, white, 85
Cos, Island of, 25
Cowpox, 101, 102
Cretins, 194
Cuckoo, 102
Culex, 234
Culicidæ, 218
Culture of germs, 65
Curie, Mme., 296

Davy, Humphry, 125
Derbyshire neck, 192
Devonshire colic, 249
Diagnosis, 107
Dioscorides, 123, 190
Diphtheria, 91
,, antitoxin, 92
,, bacillus, 92

Index

Diphtheria, mortality from, 92, 93
Disease arising from occupation, 243
Disease, causes of, 29
Drugs, value of, 179
Duncan, Dr. Matthews, 131
Dysentery, 85

ELECTRICITY as a cause of disease, 35
Electricity, effect on germs, 50
Electric light, effect on germs, 49
Elephantiasis, 225
Elliotson, Dr. John, 126
Erichsen, Sir John, 139
Esmarch, 157
Ether, 125, 129
Ether spray, 134
Ethyl chloride, 134
Eucaine, 134
Exciting causes of disease, 29

FARADAY, Michael, 126
Fever, intermittent, 198
,, remittent, 198
,, yellow, 224
Filaria, 226
File-cutters, 247
Finsen light, 301
Fleas as agents in spread of plague, 229
Flies, 215
Forde, 227
Fracture, ununited, 177
Freetown, 234

GASTRIC juice, 191
Germs, 40
,, distribution of, 42
,, effect of chemicals, 50
,, effect of cold, 45
,, effect of electricity, 50
,, effect of electric light, 49
,, effect of heat, 46
,, effect of light, 48
,, size of, 40
,, useful, 51
Glass polishers, 247
Glossine, 228
Goitre, 192
Greece, malaria in, 207
Greenland, smallpox in, 98

HÆMOGLOBIN, 260
Hæmolysis, 265
Hæmophilia, 60
Hæmorrhage, the arrest of, 150
Harvey, 28, 315
Havana, 239
Hay fever, 290
Heart, surgery of the, 168
Heat as a cause of disease, 34
,, effect on germs, 46
Helmholtz, 115
Holmes, Oliver Wendell, 130
Homer, 24
Honey, 276, 289
Hospital gangrene, 139
Hunter, John, 102
Hydrophobia, 81

ICELAND, smallpox in, 98
Idiosyncrasies, 285
Immunity, 77
,, acquired, 78
,, active, 96
,, inherited, 78
,, passive, 94
Incubator, 67
Indians, North America, smallpox among, 99
Industrial diseases, 243
Influenza bacillus, 41, 76
Inoculation for smallpox, 78, 100
Insects as a cause of disease, 213
Intermittent fevers, 198
Internal secretions, 192
Ismailia, 235
Italy, malaria in, 210

JACKSON, C. P., 129
Jamaica, 224
Jenner, Edward, 102
Jenner's inquiry, 103
Jesty, 101
Jones, W. H. S., 208
Jurin, 99

KALA-AZAR, 206
Keith, Dr. George, 131
Kitasato, 315
Klebs, 91
Koch, 315

LAENNEC, 110
Lake Timsah, 235
Larva of mosquito, 219
Larvicide, 238
Laryngoscope, 116
Laryngoscopy, direct, 118
Lead poisoning, 243
Leeuwenhoek, 55
Legal medicine, 258
Lesseps, 235
Letheon, 129

Index

Ligature, 154
Light as a cause of disease, 35
,, effect on germs, 48
,, electric, effect on germs, 49
Liquid air, 305
Lister, Lord, 136, 141, 315
Liston, Robert, 130
Local anæsthesia, 133
Lockjaw, 94
Löffler, 91
London, smallpox in, 98, 99
Long, Dr. C. W., 129
Lucas-Championnière, 146
Lully, Raymond, 125
Lupus, 301, 304

MACHAON, 24
Malaria, 198, 218
,, in Greece, 207
,, in Italy, 210
,, political importance of, 204
,, prevention of, 232
Malingering, 306
Mandragora, 123
Manson, Sir Patrick, 226
Matches, safety, 255
Match-making, 254
Mauritius, 212
Measled pork, 216
Mechanical causes of disease, 31
Medicine of the future, 313
Mercurial poisoning, 251
Mesmer, 126
Metazoites, 222
Metchnikoff, 84, 86
Mexico, smallpox in, 98
Microbes, 40
Micro-organisms, 40
Microscope, compound, 56
,, in medicine, 54
Microscopical examination of tissues, 73
Mongoose, 89
Montagu, Lady Mary Wortley, 100
Morton, Dr. W. T. G., 129
Mosquitoes, 218
Musk deer, 264
Myxœdema, 193

NÆVI, 304
Nitrous oxide gas, 124
Nose, replacement of, 172
Nymph of mosquito, 220

OPHTHALMOSCOPE, 114
Opsonins, 87
Optimum temperature, 47
Organo-therapy, 190
Organs, replacement of, 172
,, transplantation of, 172
Orvietan, 273

PABULUM, theory of immunity, 83
Painter's colic, 243
Panama Canal, 238
Paré, Ambroise, 154
Parasitic causes of disease, 37
Paraffin for a misshapen nose, 174
Pasteur, 79, 80, 81, 141, 315
Patent medicines, 184
Pearson, 125
Percussion, 108
Peruvian bark, 203
Phagocytes, 86
,, education of, 87
Phagocytosis, 86
Phosphorus poisoning, 253
,, red, 254
,, white, 254
Phossy jaw, 255
Physical causes of disease, 83
Pitchblende, 297
Plague, 228
Plasma of blood, 85
Plasmodium malariæ, 183, 221
Pleximeter, 110
Pliny, 123
Podalirius, 24
Poictou, 248
Poison bottles, 270
Poisoning, 267
Poisoning by alcohol, 283
,, by arsenic, 280
,, by brass, 256
,, by coal gas, 282
,, by copper, 279
,, by phosphorus, 253
,, by lead, 243
,, by meat, 275
,, by mercury, 251
Port-wine marks, 304
Predisposing causes of disease, 29
Pressure, diminution of, as a cause of disease, 32
Pressure, increase of, as a cause of disease, 32
Priestley, 124
Ptomaines, 277
Pulex cheopis, 229
Pupa of mosquito, 220

QUININE, 182, 241
,, free supply of, 239

Index

RABIES, 81
Radium, 296
Rats as agents in spread of plague, 229
Rays, X or Röntgen, 118
Red corpuscles, 263
Remittent fevers, 198
Reverdin, 171
Rhazes, 27
Rice, 288
Richardson, Sir B. Ward, 134
Riggs, Dr., 128
Rinderpest, 77
Ringworm, 294
Robinson, 130
Rodent ulcer, 294
Rolph, 101
Röntgen rays, 118
"Rose cold," 290
Ross, Sir Ronald, 207, 234

SABOURAUD'S pastilles, 294
Safety matches, 255
Salerno, 27
Secretary-bird, 89
Secretions, internal, 192
Self drugging, 188, 318
Shock, 159
Sierra Leone, 234
Silk for ligatures, 155
Simpson, Sir James, 131
Skiagram, 121
Skin grafting, 171
Sleeping sickness, 227
Smallpox, inoculation for, 78, 100
Snake venoms, 89
Sporozoite, 222
Spectroscope, 261
Spinal anæsthesia, 134
Stegomyia, 225, 234
Stethoscope, 111
Stethoscope, binaural, 112
Suez Canal, 235
Surgery, antiseptic, 136
,, aseptic, 149
Swabbing for diagnosis of diphtheria, 68
Sydenham, 203
Symptoms, treatment of, 181

TALIACOTIAN method, 173
Tapeworm, 216
Tetanus, 94
,, bacillus, 94
Thermometer, clinical, 112
Thiersch, 171
Tissues, microscopical examination of, 73
Tourniquet, 156
Toxin, 88, 94
Transfusion of blood, 162
,, of salt solution, 162
Traube, 84
Trichina, 37
Trichinosis, 37
Tsetse-fly, 228
,, disease, 77
Trypanosoma, 227
Trypanosomiasis, 227
Typhoid fever, bacteriological test for, 70
Type-founding, 247

UNUNITED fracture, 177

VACCINATION, 79
,, in Germany, 105
Vaccines, 95
Venoms, 89
Virus, attenuated, 79

WALCHEREN expedition, 207
Waldie, 131
Warts, 304
Warren, Dr. J. C., 129
Water, bacteriological testing of, 70
Wells, Horace, 128
Widal's reaction in typhoid fever, 70
White-lead manufacture, 246
Wiring broken bones, 175
Woolcombe, 125
Wrist-drop, 244
Writer's palsy, 257
Water gilding, 252

X-RAY burns, 295
X-rays, 118
,, treatment by, 292

YELLOW fever, 224

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